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MORPHOLOGICAL NOTES.

FROM THE BIOLOGICAL LABORATORY OF THE JOHNS HOPKINS UNIVERSITY.

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The Origin of the Organs of Salpa. By W. K. BROOKS.

[An abstract of Chapter XIV of a Memoir on the Genus Salpa, which is now in press.]

I. THE SALPA EMBRYO.

Stated in a word the most remarkable peculiarity of the salpa embryo is this: It is blocked out in follicle cells which form layers and undergo other changes which result in an outline or model of all the general features in the organization of the embryo. While this process is going on the development of the blastomeres is retarded, so that they are carried into their final positions in the embryo while still in a very rudimentary condition.

Finally, when they have reached the places which they are to occupy, they undergo rapid multiplication and growth, and build up the tissues of the body directly, while the scaffolding of follicle cells is torn down and used up as food for the true embryonic cells.

No other animal presents us with an embryonic history quite like that of Salpa, although other tunicata show something similar, but very much less pronounced. In the chapter of my memoir, on the Morphological Significance of the Salpa Embryo, I attempt to show how the life history of Salpa has come about, but we must now confine ourselves to the facts.

An imaginary illustration may help to make the subject clear. Suppose that while carpenters are building a house of wood, brickmakers pile clay on the boards as they are carried past, and shape the lumps of clay into bricks as they find them scattered through the building where they have been carried with the boards. Now, as the house approaches completion, imagine that bricklayers build a brick house over the wooden framework, not from the bottom upwards, but here and there, wherever the bricks are to be found, and that, as fast as parts of the brick house are finished, the wooden one is torn down. To make the analogy more complete, however, we must imagine that all the structure which is removed is assimilated by the bricks, and is thus turned into the substance of new bricks to carry on the construction.

Salensky (Neue Untersuchungen, &c., Naples Mittheilungen, I, 1882, and Embryonalentwicklung der Pyrosoma., Zool. Jahrbucher, IV and V, 1891) has discovered and minutely described the migration of the follicle, but he has failed to trace the history of the blastomeres, and believes that these degenerate and disappear, and that the embryo is built up of follicle cells. I find that all the follicle cells are ultimately used up as food, and that the true embryo is formed from blastomeres after the analogy of the rest of the animal kingdom.

II. THE AGGREGATED SALPAE.

During their development the aggregated salpae undergo complicated changes of position, which render the interpretation of sections very difficult, and as both Salensky (Morph. Jahrbuch, 1877, III) and Seeliger (Jena. Zeitschr., 1885) have totally failed to understand these changes, their accounts of the origin of the aggregated salpae have no permanent value.

I pointed out, in 1886 (Studies from the Biol. Lab., Johns Hopkins Univ., 1886, pp. 398–414), that the salpa chain is, morphologically, a single row of salpae, all in the same position, with their dorsal surfaces proximal or towards the base of the stolon, and their right sides on its right. The account of the origin of the aggregated salpae, which is given in this memoir, is simply an amplification and expansion of the statement which, in 1886, I made briefly and in outline.

The stolon is bilaterally symmetrical, its plane of symmetry is fundimentally identical with that of the solitary salpae, and the rudiment of each aggregated salpa is bilaterally symmetrical in the same plane, although the secondary changes begin very early, and convert the single row into a double row which comes to consist of a series of right hand salpae and a series of left hand ones placed with their dorsal surfaces out, their ventral surfaces towards the ventral surfaces of those in the opposite row, and with the left sides of those on the right, and the right sides of those on the left towards the base of the stolon. In order to illustrate these secondary changes of position let us represent the series of salpae by a file of soldiers, all facing the same way. Now imagine that each alternate soldier moves to the right, and the others to the left, to form two files still facing the same way. Now let them face about so that the backs of those in one row are turned towards the backs of those in the other row. They will now represent two rows of salpae in their secondary positions.

To make the illustration more perfect suppose that, instead of stepping into new places the soldiers grow until they are pushed out by mutual pressure, and suppose that their heads, growing fastest, form two rows while their feet still form one row, and suppose furthermore that, as each soldier rotates, his feet turn first, and that the twisting runs slowly up his body to his head which turns last. We must also imagine that these various changes all go on together, and that while they are taking place each soldier not only grows larger, but also develops from a simple germ to his complete structure.

Salensky regards the stolon as two rows of rudimentary salpae, and while Seeliger correctly states that they at first form a single row, he has failed to discover the rotation, and believes that they arise on the stolon in their final positions, and he has, therefore, failed as completely as Salensky, in his efforts to trace the origin of their organs.

III. THE ECTODERM OF THE SALPA EMBRYO.

At an early stage of segmentation, some of the blastomeres move upwards and pass out of the follicle on the middle line of the dorsal surface, where the two layers of the follicle are continuous with each other. I have given reasons for believing that this is the spot which was once occupied by the blastopore. These ectodermal blastomeres thus become extra-follicular, although they are covered for a time by the capsule of epithelium, which Salensky has called the "Ectodermkeim." They give rise, by cell division, to the ectoderm, which spreads from the dorsal middle line downwards and outwards over the embryo, pushing off and replacing the cells of the capsule. The ectoderm has a growing edge, like that of meroblastic embryos, and it does not close in completely on the ventral middle line until after birth.

Salensky (Neue Untersuchungen. Mith. a. d. Zool. Station zu Neapel I. 1882) has figured the migration of blastomeres to an extra-follicular position on the dorsal surface of the embryo, in several species, although he regards them as discarded blastomeres, and derives the ectoderm from other sources. They are clearly shown in Salpa pinnata in his Plate 12, Fig. 26; in Salpa pectinata in his Plate 23; and in Salpa fusiformis in his Plate 24, Fig. 3, where they are marked by the letters *Eckb*, which might be supposed to stand for "ectodermal blastomeres" if he did not tell us explicitly, on p. 389, that the ectoderm of this species is derived from the epithelial capsule ("Epithelhügel").

The ectodermal blastomeres seem to be more conspicuous in Salpa fusiformis than in other species, for Salensky says, p. 345, that while the epithelial capsule ("Ectodermkeim") is generally separated very sharply from the embryonic cell mass, it is at one end of the embryo so intimately related to the follicle cells ("gonoblasts") that it is difficult to determine the boundary between them, *and the blastomeres which lie directly at this spot* are covered only by the epithelial capsule ("Ectodermkeim"). At a later stage he says, p. 350, that the epithelial capsule ("Ectodermkeim") contains cells which differ greatly among themselves in both size and form. Some of them are similar in appearance to the cells of the epithelial capsule, as already described, at an earlier stage, and differ from them only in being more flattened. "*The others Eckb are very much larger and very different in structure, and contain a nucleus which is very similar to that of the blastomeres. The appearance of these cells suggests that they are blastomeres which have passed out from the cell mass.*"

Salensky believes that the ectoderm of Salpa democratica is derived from the oviduct, and that, in all other species, it is derived from the epithelial capsule ("Epithelhügel," "Ectodermkeim"), but I think all will agree that his position is untenable until he has traced the history of these extra-follicular blastomeres, and has proved that they take no part in its formation.

I have shown that they do give rise to the ectoderm, and that the epithelial capsule is a transitory structure which is lost as the ectoderm replaces it.

IV. THE ECTODERM OF THE STOLON AND THAT OF THE AGGREGATED SALPAE.

All agree that the ectoderm of the stolon is derived, directly, from the ectoderm of the embryo. In one minor point my observations show that the older accounts are incorrect. It is usually stated that the ectoderm of the stolon is *pushed* out into a tube by the growth of the other constituents of the stolon, and Seeliger says (Die Knospung du Salpen, Jena. Zeitschr., 1885), p. 13, that it is an evagination ("Ausstülpung") from the ectodermal epithelium of the embryo. This is not literally true, for the ectoderm itself takes a most active part in the formation of the stolon. This is marked off on the body of the embryo by a fold of ectoderm, which pushes backwards from its tip to its base, so that it is folded off from the body of the embryo rather than pushed out, and, in the young stages of Salpa pinnata at least, its differentiation from the body of the embryo is chiefly due to the active growth of this ectodermal fold.

The ectoderm of the aggregated salpae has been correctly held to be directly derived from the ectoderm of the stolon by all students except Todarro. My own observations show also that the multiplication of the ectoderm cells is the chief agent in the segmentation of the stolon; that the nerve tube and the perithoracic tubes are cut up into vesicles by the growth of the ectodermal folds, and that these are the chief agents in the segmentation of the endodermal tube and the genital rod.

V. THE NERVOUS SYSTEM OF THE EMBRYO.

Little can be said of this without illustrations. The caudal nervous system is represented by scattered blastomeres, which soon degenerate and disappear. The ganglion is formed as an invaginated fold of the somatic layer of the follicle, and the ganglionic blastomeres pass into it from the ectodermal ridge and become completely folded in among the follicle cells. The ganglionic rudiment soon looses its connection with the somatic layer and unites with the visceral follicle cells in the region of the roof of the anterior end of the pharynx.

VI. THE NERVE TUBE OF THE STOLON.

This is formed from the ectoderm on the middle line of the upper surface of the stolon, at the point where its ectoderm folds upon itself to become continuous with that of the embryo. The straight stolon of Salpa pinnata is so favorable for studying its origin, and the evidence that it is ectodermal is so simple and clear in this species that it does not seem necessary to devote much space to the discussion of the observations which have been made on twisted stolons like that of Salpa democratica, where it is very difficult to study the young stages by sections. The connection between the nerve tube and the ectoderm is shown only by very young stolons, and for only a short time, and the two structures are quite independent in older stolons.

Of the various writers on the subject, Kowalevsky (Beiträge, &c., Nachr., d. k. Gesellsch. der Wissensch, zu Göttingen, 1868, 19) seems to regard it as mesodermal in origin. Salensky in his paper on the budding of Salpa (Morph. Jahrb., 1877, III) says nothing about its origin. Todarro (Sopra lo svilluppo, &c., 1875) derives it, as he does all the other organs of the stolon, from a single germoblastic cell, but I have already shown that his germoblastic cell is a migratory placenta-cell, and all recent writers have justly rejected his account of the stolon. Seeliger believes that in the stolon of salpa and also in the buds from the ascidiozooids of pyrosoma, it is mesodermal in origin, and that it is derived from an indifferent mass of mesoderm, which, in the young stolon, fills all the space between the ectoderm and the endodermal tube, and becomes differentiated into the nerve tube and other organs of the stolon.

I have not found, at any stage, anything in the straight simple stolon of Salpa pinnata, corresponding to his indifferent mesoderm, although I have studied it in serial sections in the three rectangular planes, and I do not hesitate to affirm that Seeliger has been misled through the selection of a most unfavorable species.

As I have not myself studied pyrosoma, I am not in a position to make any comment on his account of this animal, although Salensky (Embryonalentwicklung der Pyrosoma, Zool. Jahrbucher, V, 1891) has recently shown that the ganglia of the four primary ascidiozooids which are produced from the stolon of the cyathozooid, as well as the ganglion of the cyathozooid itself, are derived from the ectoderm.

VII. THE GANGLIA OF THE AGGREGATED SALPAE.

The nerve tube arises as a solid rod, but it soon acquires a lumen. As the ectodermal folds grow inwards, and mark out the bodies of the salpae, they cut the tube up into a series of ganglionic vesicles, one for each salpa, with cavities which are segments of the lumen of the tube. The presence of the ectodermal folds and the growth of the ganglia soon cause crowding and pressure, and the ganglia becomes flattened in the axis of the stolon and elongated transversely. As the oral ends of the pharyngeal pouches grow up to the level of the ganglion, and push in between it and the ectoderm, the crowding becomes still greater and the single series of ganglia breaks up into two rows, which move to the right and left alternately, as they grow, and the ganglion of a right hand salpa soon comes to lie far away from that of the left hand salpa with which it was at first in contact. It is convenient to speak of this change as a "migration" of the ganglion, but there is actually no migration, for the ganglion of each salpa lies, from the first, in its final position on the middle line, dorsal to the oral end of the pharynx, and the apparent migration is the result of secondary changes in the position of the bodies of the salpae, and is not due to any change in the relation of the ganglion to other organs of the body.

Both Salensky and Seeliger have figured and described the "migration" of the ganglion, but as they have failed to discover the rotation of the bodies of the salpae they regard it as an actual migration, and have completely misunderstood its true relation to the other organs of the body.

My sections show that the "sub neural gland," or "ciliated funnel," is an outgrowth from the pharynx, and that its intimate relation to the ganglion is secondary. Seeliger believes that the ganglionic rudiment gives rise to both the ganglion and the ciliated funnel, although he admits, p. 20, that his observations are not conclusive.

VIII. The Perithoracic Tubes and the Atrium or Cloaca of the Salpa Embryo.

It is not possible to describe the history of these structures intelligibly without figures. They arise as involutions of the somatic layer of the follicle, and they attain to their final form before the blastomeres begin to replace the follicle cells; so that there is a stage when the complete perithoracic system is outlined in cells which do not come from the fertilized egg, but from the follicle.

This system makes its appearançe, as it does in the embryos of ordinary tunicata, as a pair of lateral perithoracic invaginations; although, in the salpa embryo, these are formed from the somatic layer of the follicle. They push inwards, penetrate the visceral mass of follicle cells, and meet and unite on the middle line to form the median atrium or cloaca. From the level of the median atrium each perithoracic tube pushes downwards to the region where the cavity of the pharynx is subsequently to be hollowed out in the visceral mass. The two tubes soon lose their communication with the exterior, and the median cloacal aperture is an independent opening which is formed later. After the pharynx is formed each perithoracic tube unites with it to form a gill slit. Finally, after the perithoracic system is completely outlined, its follicular cells degenerate and are gradually replaced by blastomeres.

Our knowledge of the perithoracic system of salpa, in both the solitary and the aggregated form, is in great confusion.

Salensky has described the origin of the "gill," and of the median atrium or cloaca of the embryo, in a number of species, but the reader of his papers will search in vain for any basis of comparison with other tunicata, or even for any fundamental unity in his account of the various species of salpa, and his papers contain internal evidence that he has misinterpreted his observations.

Uljanin holds that the perithoracic structures of doliolum are not homologous with those of the ascidian, and Salensky holds the same view regarding salpa. He says that the "gill" is part of the body cavity which is shut in by folds in the walls of the pharynx, and that the cloaca is not an independent chamber but a part of the pharynx which is shut off by these folds. A careful study of his description, especially pages 119, 200, 224, 225 and 229 of his first paper, and pages 114, 139, 160, 163, 338, 339 and 354 of his second paper, will show that his views not only involve this conclusion but that they would also force us to believe that the "gill" and cloaca of one species of salpa are not homologous with the same structures in another species, for his account of their origin in Salpa democratica and Salpa pinnata has almost nothing in common with his account of them in Salpa africana, Salpa pectinata and Salpa fusiformis.

In his first paper on Salpa democratica he says that, like Leuckart, he regards the gill as part of the inner mantle or branchial sac; that in origin it is nothing more than a strongly developed ridge or thickening on the middle line of the dorsal surface of the pharynx, and that, on each side of it, the cavity of the pharynx is pushed upwards to form a pair of pouches, which soon meet and unite above the cloaca. In this way the gill ridge is transformed into a rod, and the rod, which is at first solid, becomes tubular by the conversion of its axial cells into blood corpuscles.

In this account of the origin of the perithoracic structures of Salpa democratica the only point of agreement with my own observations on Salpa pinnata is his statement that the gill is, at first, solid, and that its central cells are set free as development progresses. In his second paper he retracts this statement, and says, p. 139, that while his studies of the embryo of Salpa pinnata have in other respects confirmed his account of the origin of the cloaca and gill of Salpa democratica, they show that the gill is, in its origin, a hollow diverticulum from the body cavity. He here describes the cloaca and gill as arising in a totally different way in Salpa africana, p. 160 and 163, Salpa punctata, pp. 338–9, and Salpa runcinata (fusiformis), p. 354, for while he says that, in these species, as in Salpa democratica and Salpa pinnata, the cloaca is part of the pharynx, it is separated off by two folds, Taf. 24, Figs. 7 and 8, *Kestp*, of its lateral walls, which grow towards each other and unite on the middle line to form a horizontal diaphragm, which shuts off the dorsal cloacal division of the pharynx from the ventral chamber. The diaphragm then becomes separated, at its sides, from the lateral walls of the pharynx, so that a secondary communication is established on each side between the upper and the lower chamber, while the middle portion of the diaphragm becomes the gill.

It will be seen that, according to this account, the "gill" of Salpa democratica and Salpa pinnata arises as an unpaired median dorsal fold, while he describes it in the other species as arising from a pair of lateral folds; in the first two species the gill-slits or openings by which the two chambers communicate at the sides of the gill are primary, while in the others they are secondary; in the first two the cloaca is a secondary chamber formed by the union of the two pouches from the pharynx, while in the other species it is primary.

It does not seem possible to reconcile these statements with each other, and any attempt to bring all or any of them into accord with my own account seems hopeless. More critical examination will show, however, that his observations are rather imperfect than inaccurate, and that his errors are errors of interpretation.

My own observations show that the perithoracic tubes and atrial chamber are formed before the cavity of the pharynx is hollowed out in the mass of visceral follicle cells, and Salensky has, in these early stages, mistaken them for the pharynx or "primitive digestive cavity." This is well shown by the comparison of the two longitudinal sections of embryos of Salpa runcinata, which are shown in his Plate 24, Fig. 4 and Fig. 9. These figures show clearly that the so-called "Darmhöhle" *Pmd*, of the younger embryo, is the cloaca and not the pharynx of the older one. This is proved even more conclusively by comparing his Fig. III of Plate 8 with Fig. V, for the chamber which is marked *Pdmh* in the younger embryo is obviously the one which is marked *Kl* in the older one.

The perithoracic tubes are actually shown in many of his figures, notably in his Plate 6, Fig. V, *pin*, where they are marked *Drm*. They are also shown in his Plate 12, Fig. 24, at *Dh*, and their union on the middle line to form the cloaca is shown at *D* in his Fig. 25, and at *D* and *Dh* in his Fig. 28 A. In the series of sections on his Plate 13, Fig. 31 A shows the two perithoracic tubes, cut above the level of the atrium. His Fig. 31 B and 31 C show the atrium, and his 31 D shows the two tubes below the level of the atrium but above the level of the pharynx.

Salensky regards these structures as the halves of the primitive digestive cavity which, he says, p. 114, arises in Salpa pinnata as two independent and completely separated halves, and he describes the atrium and gill as arising at a very much later stage, in the way which is represented in his Plate 14, Fig. 37, and Plate 15, Fig. 39.

In his Plate 24, Fig. 1 appears to be a section through one of the perithoracic tubes, *Pmdh*, before it has lost its connection with the surface, and in his description of this figure, p. 346, he says that the triangular primitive digestive cavity is united above to the epithelial capsule (Ectodermkeim), and on both sides of the tip are the reflections of the somatic layer of the follicle (follicular wall) already noted, where this passes over into the visceral (gonoblastic) layer.

Salensky correctly describes the manner in which the perithoracic structures (primitive digestive cavity) acquire their first epithelial lining by the migration of the somatic layer of the follicle (follicular wall), and, I believe, that I have now carried the analysis of his observations far enough to prove that they contain internal evidence of the correctness of my own account.

IX. The History of the Perithoracic Structures of the Aggregated Salpa.

The rudiment of each chain salpa contains two perithoracic vesicles, a right one and a left one, derived from the right and left perithoracic tubes of the stolon. These vesicles give rise to the perithoracic system and to nothing else. Throughout its whole history the perithoracic system is bilaterally symmetrical, although this symmetry is hidden by the changes which take place in the position of the plane of symmetry during growth.

As the right and left pharyngeal pouches are formed, the perithoracic vesicles are folded inwards by the growth of the ectodermal folds of the stolon, so that each one of them lies on the proximal or dorsal surface of its corresponding pharyngeal pouch. While the vesicles are hollow from the first, they have at first no communication with the cavities of the pharyngeal pouches. The first trace of the gill-slit is a fold or diverticulum in the dorsal wall of the pharyngeal pouch. This elongates and soon unites with the wall of the perithoracic vesicle to form a gill-slit. Soon after these are formed the posterior ends of the bodies of the salpae begin to push out to the right and left, in such a way that the elliptical cross-section of the body becomes converted into a wedge, with its narrow edge on the left side of a right hand salpa, and on the right side of a left hand salpa. The two perithoracic vesicles are differently affected by this change, for while the one nearest the pointed end of the wedge is compressed in the line of the axis of the stolon the other is not. Thus the left perithoracic vesicle of a right hand salpa, and the right one of a left hand salpa become flattened and elongated towards the middle line, while the other remains more nearly circular in section. Their relations to the morphological middle plane are fundamentally identical, but as the middle plane itself gradually moves outwards there is an apparent asymetry.

Each perithoracic vesicle now becomes extended towards the middle line, where they unite to form the median atrium or cloaca, to which they contribute equally, although the position of the body is such that sections transverse to the long axis of the stolon might easily be misinterpreted and held to prove that the whole median atrium of a right hand salpa arises from the left vesicle alone, and that of a left hand salpa from the right one alone. The secondary changes of position are, however, of such a character that it is impossible to describe them in detail without figures.

Seeliger's account of the perithoracic structures of Salpa democratica, pp. 18, 48 and 63, serves to show how difficult the study of a simple structure may be made by a slight change of position; for phenomena which can be observed with ease in the straight stolon of Salpa pinnata are so obscure in Salpa democratica that all the industry and technical skill which Seeliger has devoted to this species has had very little outcome.

His account of the history of the perithoracic system is essentially as follows: The perithoracic tubes, which he calls the Seitenstränge, are mesodermal in their origin, and are specialized out of a mass of mesoderm cells which gives rise also to the nerve tube of the stolon, and to the genital rod. The mesoderm passes into the stolon from the body of the embryo in an unspecialized condition, and gradually becomes differentiated into these organs after the stolon is formed. The folds in the ectoderm of the stolon divide the Seitenstränge into a series of solid masses at the sides of the stolon, between the ectoderm and the endoderm. These bodies are equal in number to the future salpae and not twice as numerous. As each salpa is constricted off from the tube it carries with it the greater part of one of these masses of cells, from one side of the stolon, and the lesser portion of the one on the opposite side. These two masses are not bilaterally placed in the body, but are on the middle line, the larger one being dorsal or neural and the smaller one ventral or haemal. The latter gives rise to the heart and to the eleoblast, while the larger one, on the neural surface, gives rise to most of the mesoderm of the chain salpa, and also to a cloacal vesicle which is median and unpaired.

The vesicle becomes distended, and at two points, one on each side of the middle line, it unites with the wall of the branchial sac, and the cloaca and the branchial chamber thus become connected through the two gill slits, while a similar union with the ectoderm in the middle dorsal line forms the cloacal aperture. Seeliger's account is perhaps as near the truth as one could hope to get by the study of transverse sections of the twisted stolon of Salpa democratica, but a very little study of sections in other planes in more favorable species will show that he has completely failed to understand the subject, and that his account has no permanent value.

It is not only irreconcilable with my own observations but also with our knowledge of Pyrosoma, for both Seeliger (Pyrosoma, pp. 622–624) and Salensky (Pyrosoma, pp. 31–36) state that in this genus the perithoracic system is bilaterally symmetrical; that each bud has two perithoracic vesicles, which are not dorsal and ventral but right and left; that each of them unites with its own side of the pharynx to form the gill slits before the two vesicles unite with each other to form the median atrium, and that this arises, as it does in the aggregated salpa, on the dorsal middle line, by the meeting and union of diverticula from the two vesicles, and that the external aperture arises still later, as it does in salpa, as an independent aperture on the middle line.

The perithoracic vesicles are derived, as I find that they are in salpa, from the right and left perithoracic tubes of the stolon; but, in the primary ascidiozooids at least, these are continuous with the perithoracic tubes of the primary embryo or cynthozooid, where, according to both Kowalevsky and Salensky (pp. 466, 473–475), the evidence that they arise as paired ectodermal invaginations from the surface of the body is clear and unmistakable.

X. The Digestive Organs of the Embryo.

The cavity of the pharynx arises, in the mass of visceral follicle cells, by the degeneration of these cells. Its endodermal epithelium is derived from the blastomeres, and the gut is formed later as a diverticulum from the pharynx.

Salensky's account of the origin of the digestive organs is scattered through the pages of his memoir in such a way that it is hard to review, and as I have shown that he has, in the youngest embryos, mistaken the two perithoracic tubes for the pharynx; that he has at a somewhat older stage mistaken the median atrium or cloaca for the pharynx, and that he has failed to discover the actual pharynx during its early stages, it is clear that his description has no value.

XI. The Endodermal Tube of the Stolon and the Digestive Tract of the Aggregated Salpa.

The endodermal tube of the stolon is formed as a diverticulum from the ventral middle line of the pharynx of the solitary salpa, and its communication with the cavity of the pharynx is retained throughout the whole history of the stolon. The thickened side walls of the endodermal tube are derived from the two endostylic folds of the pharynx of the embryo.

The pharynx of the aggregated salpa is, morphologically, bilaterally symmetrical with the middle plane of the stolon, although this fact is obscured by the secondary changes of position. It is formed from two pharyngeal pouches, a right and a left, from the sides of the endodermal tube of the stolon. The oral ends of these pouches grow forwards and quickly meet and unite on the morphological middle line to form the oral end of the pharynx. The aboral ends grow backwards and approach each other on the middle line, and finally unite, although they remain separate very much longer than the oral ends.

In a strict sense the pharynx is not actually but only apparently double in origin, for the middle section or endodermal tube is not double. Fundamentally it is a single unpaired expansion of the endodermal tube, but at the time when it elongates towards the oral and aboral ends of the body the middle line is occupied by the blood tubes, and it pushes along the sides of these structures and does not become complete in the middle line until a much later stage.

The post pharyngeal gut arises as a blind diverticulum from the aboral end of the right pharyngeal pouch. The part of the diverticulum nearest the pharynx becomes the oesophagus, and the stomach and intestine are developed from its blind end. In all the species I have studied the intestine bends to the left past the stomach to open dorsally into the median atrium, and the digestive tract assumes the form of a figure 8, which is persistent in most species, although in Salpa pinnata the intestine gradually moves downward as development advances, until it finally becomes ventral to the stomach.

As the gut arises, in both right hand and left hand salpae, from the right pharyngeal pouch, and since the distortions which are produced by pressure and by the changes of position affect the right hand pouch of a right hand salpa just as they affect the left hand pouch of a left hand salpa, and since they affect the other pouches in quite a different way, the history of the gut in a right hand salpa is superficially very different from that of a left hand salpa, although fundamentally they are exactly alike.

While Salensky, in his first paper on the budding of salpa, describes the endodermal tube, he says that it takes no part in the construction of the salpae, and that their digestive organs are derived from that part of the stolon which I have called the genital rod. Seeliger, a few years later, pointed out Salensky's error, which he has himself admitted in a recent paper (Pyrosoma, p. 78).

Seeliger's account of the origin of the endodermal tube and digestive organs is given on pp. 14, 18, 26–34, and 54–62, of his paper on the budding of salpa. He shows, p. 14, that the endodermal tube of the stolon is derived from the pharynx of the embryo, with which it at first communicates, although he says that this connection is soon lost, while my observations show that it is persistent at all stages in the history of the stolon of Salpa pinnata and Salpa cylindrica.

He gives, p. 18, a good description of the segmentation of the side walls of the endodermal tube, but he says that the endoderm and mesoderm are the active agents in the segmentation of the stolon, while my own observations show clearly that the most active agent is not the endoderm nor the mesoderm, but the ectoderm.

He states, correctly, that the structures which I have called the pharyngeal pouches arise from the side walls of the endodermal tube, and that two of them enter into the body of each salpa, but here the agreement between his account and my own observations ends, although his figures show clearly that the species which he studied, Salpa democratica, agrees in all essentials with those which I have studied.

While the two pharyngeal pouches are actually right and left, he regards one as dorsal and the other as ventral, and says that the dorsal one is largest, and that it lies, from the first, on that side of the stolon to which the salpa belongs, and that it runs through the whole length of the body of the young chain salpa and opens, in its middle region, into the horizontal endodermal tube of the stolon, so that a neural and a haemal part are distinguishable.

His account and figures show that his so-called dorsal pouch is actually the right pouch of a right hand salpa, or the left pouch of a left hand one.

In other respects his account of the origin and primary relations of this pouch is correct, although he fails to discover that the history of the second pouch is exactly the same.

He describes the second pouch as ventral, and much smaller, and as lacking the oral end, and he says that it looses, long before the dorsal pouch, its connection with the horizontal tube, and becomes a closed vesicle, and that, as the hinder ends of the bodies of the salpae diverge from each other, the smaller ventral pouch pushes further backwards than the larger dorsal one, and that the hindermost end of the dorsal pouch gives rise to a diverticulum which grows round the hinder surface of the ovary to unite with the ventral pouch. The dorsal pouch gives rise, he says, to the pharynx, on the ventral surface of which the endostyle is developed, while the oesophagus, stomach and intestine are formed from the rudiment which has arisen at the posterior end by the union of the two pouches.

It is not necessary to enter into a more minute analysis of his description, for comparison will show that he has been misled by his erroneous conception of the primary position of the buds, and has mistaken the symmetrical right and left pouches for unpaired dorsal and ventral ones.

His more recent account of the origin of the post-pharyngeal gut of pyrosoma (Pyrosoma, pp. 23–25) is very similar to what I have found in salpa, for he says, pp. 615–622, that while it arises as a pair of folds from the pharynx, these soon unite to form an unpaired diverticulum, which afterwards becomes differentiated into oesophagus, stomach and intestine; that its pharyngeal end becomes the oesophagus, while the intestine arises from its blind end and ultimately acquires an anal opening into the median atrium.

Salensky's account of the origin of the gut in pyrosoma is quite different, however, for he says (Pyrosoma, pp. 69–72) that it is bilateral in origin and arises as a pair of folds from the sides of the aboral end of the pharynx, which unite with each other to form a horse-shoe shaped canal. If I understand his description, he holds that the right fold forms the oesophageal portion of the gut, and the left one the intestinal portion, and that both open at first into the pharynx, although the intestine soon looses this connection and acquires a new anal opening into the median atrium.

BALTIMORE, April 25th, 1893.

The Nutrition of the Salpa Embryo. By W. K. BROOKS.

As the mammalian placenta nourishes and aerates the blood of the fœtus by the diffusion of gases and food in solution through the walls of the blood-vessels, it has been generally taken for granted that the placenta of salpa performs its function in the same way, and it has been described as divided into a fœtal chamber and a maternal chamber, although its cavity is in reality part of the body cavity of the chain-salpa, and the blood which circulates in it that of the chain-salpa. The salpa embryo is bathed by the water which is constantly flowing past it, and it is therefore in very much closer relation to the external world than a mammalian embryo, shut up in the interior of a large thick-walled body. There does not seem to be any need in salpa for a respiratory placenta, and its thick spongy walls seem to indicate that it is not respiratory. We find in its structure nothing like the interlacing villi of the mammalian chorion, and the sections show that the embryo is nourished in a way quite unlike anything which has been described in the mammalia.

The subject is a very interesting one. The rapid growth of the salpa embryo is one of its most conspicuous characteristics, and the nutrition which this rapid growth demands is secured by two very peculiar organs, the follicle and the placenta.

While the egg at the time of fertilization is very minute, the embryo at the time of birth is enormous, as compared with the size of the chain-salpa which carries it, and it certainly increases many thousandfold during development. The growth is only partially due to cell multiplication, and it is in part a result of the growth of the individual cells, for instead of growing smaller with repeated division, they actually increase in size in all parts of the body.

This growth of the cells is one of the most notable peculiarities of the salpa embryo, and in many parts of its body cells as large as the original ovum are found. The growth sets in very early, and it goes on uninterruptedly throughout the whole fœtal life, so that the embryo becomes gigantic as compared with the body of the chain-salpa which contains it. Quoy and Gaimard describe an embryo, two inches long at birth, in a salpa (S. forskalii) a foot long, and Leuckart says that the embryo of S. democratica at birth is two-fifths as long as the chain-salpa which carries it. The fully grown embryo of S. hexagona is almost as long in comparison with the chain form of the same species.

It is not unusual for the embryos of viviparous animals to gain slightly in size and weight before birth, but, as Leuckart points out, the mammals are the only animals which exhibit anything comparable to the rapid growth of the salpa embryo from a minute egg, and the history of the salpa embryo at once calls to mind that of the placental mammals; nor is this resemblance entirely superficial, for in both the mammal and in salpa we find an especial fœtal organ, the placenta, for the purpose of affording to the growing embryo an abundant supply of nutriment.

The resemblance between the fœtal life of salpa and that of a mammal is most remarkable, and it is all the more noteworthy since we may be absolutely confident that the placenta of salpa is an independent acquisition, entirely without genetic relation to that of mammals.

No modern writer except Todarro has ventured to regard the two structures as homologous, and their phylogenetic independence is so obvious that it is not necessary to discuss it, although a greater physiological and anatomical resemblance than the facts warrant has usually been assumed.

We should hardly expect fundamental similarity in structures of diverse origin. On the contrary, we might reasonably look for profound differences between the placenta of salpa and that of the mammals.

The various writers on salpa, while recognizing this fact, and while pointing out the great differences in the way in which the placenta is formed in the two cases, have nevertheless assumed, either explicity or by implication, a much greater resemblance to the mammalian placenta, in structure and in function, than actually exists. The later writers say very little about the function of the placenta of salpa, but they assume a fundamental similarity to its function in mammals.

So far as it is in both cases an organ for supplying the embryo with nutritive matter, derived from the blood of the supporting organism, the resemblance is real, but it goes no farther than this, and the way in which the nourishment is conveyed to the embryo is totally unlike; a fact which has never been described nor even noted.

In the mammalian placenta the blood of the embryo, as it circulates through the villi of the chorion, is brought into such close contact with the blood of the mother, that diffusion takes place through the separating walls, and thus the blood of the fœtus is oxidized, relieved of its waste products, and supplied by diffusion with nutritive matter in solution.

Notwithstanding the very intimate union between the blood-vessels of the fœtus and those of the mother, there is no direct communication between them, and nothing except gases and liquids can pass from the body of the parent to the body of the child, without the violent rupture or perforation of the walls of the vessels, unless, perhaps, some very minute bacteria are an exception.

It has been generally assumed that this must be true of salpa also. Thus Barrois says, incidentally and very briefly, p. 495, that the function of the placenta of salpa is to bring about by osmosis an interchange of fluids between the blood of the parent and that of the embryo, as in the placenta of a mammal.

The subject has received very little attention, but as no one has ever commented upon the view set forth at considerable length by Leuckart, pp. 61 and 62, this may be regarded as the accepted view. He says: "The histological differentiation of the organs and tissues of the embryo is accelerated, to a high degree, by the circulation in the body of the young salpa, which is completely separated from the circulation of the mother. At no time does the blood of the mother pass through the wall of the placenta into the body of the embryo. The transfusion between the mother and the fœtus is, as in the mammals, purely endosmotic, through the substance of the placenta, and it is most essentially facilitated by the movement of the blood, both in the embryo and in the chain-salpa.

"The upper wall of the placenta, which is the peculiar seat of the process of diffusion, projects into the body of the embryo, and is surrounded by the median ventral blood sinus. As the blood corpuscles of the embryo are much smaller than those of the chain-salpa, it is easy to see that no mingling takes place."

It is probably true that no transfusion of blood corpuscles takes place, and it is difficult to show from the study of sections of hardened specimens that no serum from the blood of the chain-salpa is diffused through the wall of the placenta, although its great thickness seems to be a very unfavorable condition for this purpose, and I shall show farther on that the mechanism of nutrition is very different from that of mammals; that this is effected by the actual migration of great placenta cells into the body cavity of the embryo. The placenta is an organ for the nourishment of the placenta cells by the blood of the chain-salpa; and the subsequent degeneration of these cells, after they have migrated into the body of the embryo, supplies the material for the growth of the embryo. This is in all probability the only function of the placenta, for there does not seem to be any need for an especial apparatus for oxidation, or for the removal of waste products. The salpa embryo stands in much more direct relation to the external world than the mammalian embryo. It projects into the cloaca of the chain-salpa, and is freely exposed to the constant current of fresh sea-water which flows around it, and its thin surface seems to be much more favorable than the thick wall of the placenta for the diffusion of gases. During the later stages of fœtal life its own mouth is open, its muscles contract, and there is no reason why it should not breathe for itself exactly like an adult. I therefore regard the placenta as a nutritive organ, pure and simple, and it serves its purpose not by the diffusion of a fluid, but by the transportation of solid food into the body of the embryo. From this point of view it is clear that those investigators who have described it as divided into a fœtal chamber and a maternal chamber have been misled by an erroneous notion of its function.

The detachment of the placenta cells has been observed and noted by both Salensky and Barrois, but it has been regarded as a destructive change and as a sign that the organ has served its purpose and has become superfluous.

It has been assumed that it reaches its perfect form and serves its purpose, and that it then degenerates and breaks down, and no importance has been attached to the process of degeneration, as it has not been regarded as significant.

No note has been made of the very early stage at which degeneration begins, nor of the fact that it is initiated as soon as the embryo begins to grow, and long before it has reached half or a quarter of the size which it is to have at birth.

This is hard to explain so long as the disintegration of the placenta is regarded as its destruction, but it becomes quite intelligible as soon as we learn that the detachment of the placenta cells, instead of marking the end of its functional life, is actually a manifestation of its useful activity.

These strings of cells multiply at their lower ends by direct division of their nuclei, and as the new cells which are thus formed push up towards the top, they grow very large, while their nuclei become filled with diffused chromatin granules. In Salpa hexagona these cells ultimately reach the top of the placenta, where they gradually become elongated and irregular, and then break through into the body cavity of the embryo as the migratory follicle cells.

While the details are slightly different in Salpa pinnata, placenta cells migrate bodily into the embryo in the same way.

The rapid growth of the embryo seems to be most important to salpa, and while we know almost nothing of its birth rate, the quickness with which the surface of the ocean becomes covered with salpæ of all ages in a long calm, shows that the animals are most prolific, and the complicated structure of the organs for nourishing the embryo shows that every provision is made for rapid growth.

The placenta is not the only nutritive organ, for the follicle also makes most important contributions to the supply of material which is available for the construction and rapid completion of the body of the embryo, and while I have spoken of the segmentation and the formation of the blastodermic germ layers as retarded, the retardation is probably not actual, but only relative, and the process of development is, on the whole, accelerated by the presence of the follicle, and by its share in the growth of the embryo.

The ultimate fate of all the follicle cells is the same, and they may be found, in the sections, detaching themselves and degenerating, first, in the somatic layer of the embryo; secondly, in the somatic follicular lining of the perithoracic structures; third, in the cavity of the pharynx; fourth, in the visceral mass outside the digestive cavity, and last, in that part of the placenta which is derived from the somatic layer of the follicle.

While it is not possible to trace the history of every cell from first to last, we have as ample evidence as we could hope from sections, that the function of the follicle of salpa is exclusively nutritive; that it is transitory and embryonic, and that the tissues of the embryo are not built up out of follicle cells, but from blastomeres, after the analogy of all the rest of the animal kingdom.

Notes upon an apparently new species of Octacnemus, a deep-sea, Salpa-like Tunicate. By MAYNARD M. METCALF.

With the collections of Salpa sent to Professor Brooks by the United States Fish Commission are fifteen individuals and fragments of individuals of Octacnemus, which Professor Brooks has kindly handed to me for study. All are so very badly torn and mutilated that it is useless to attempt any thorough study of the species. Some points, however, can be made out.

The occurrence of the animal in a new locality is itself of interest. The specimens were dredged by the United States Fish Commission steamer Albatross in 1050 fathoms of water off Port Oteoay, Patagonia. The Fish Commission label reads as follows:

NUMBER.	DATE.	HOUR.	LATITUDE.	LONGITUDE.
2788	Feb. 11, 1888.	4.25 p. m.	45° 35′ S.	75° 55′ W.

TEMPERATURE.			DEPTH IN FATHOMS.	NATURE OF BOTTOM.	LOCALITY.
AIR.	SURFACE.	BOTTOM.			
57°	58°	36.9°	1050	Green Mud.	Off Port Oteoay, Patagonia.

The specimens I have studied agree with the figures and description given by Moseley and Herdman in many points, but show one fundamental and several minor differences.

External appearance.—The form and arrangement of the oral disc and the eight tentacles is as in Octacnemus bithyus, save that the tentacles do not have emarginate tips [Fig. 4 and Fig. 6]. In one small individual, 3 cm. long, the oral disc has no branchial aperture. The animal is not flattened in a horizontal plane as in O. bithyus, but is somewhat hour-glass shaped, with the surface of attachment at one end and the oral disc with its circle of eight tentacles at the other end [Fig. 6]. The atrial aperture has a different position from that of O. bithyus, not being raised on a papilla as figured by Moseley, nor situated on a posterior process of the body as in the specimens examined by Herdman, but being situated just outside the oral disc, below the tentacles, in the same interradius as the branchial aperture [Fig. 5 and Fig. 6, *A*, *a*]. Around both branchial and atrial apertures are circular thickenings of the mantle and test [Fig. 5] in which I can distinguish no muscle fibres. The thickenings cannot, then, be regarded as branchial and atrial sphincters. Dimensions of an average specimen—height, 4½ cm.; diameter at base, 2½ cm.; diameter of oral disc, exclusive of tentacles, 2 cm.; length of tentacles, 2 cm.

The animal is firmly attached by its whole base. When torn from its support the surface of attachment has a woolly appearance [Fig. 6], due to the innumerable, delicate, matted fibres, by which it had grown to its apparently solid support, though according to the label the bottom from which it was dredged was composed of green mud; the appearance of these woolly fibres suggests that the support must have been solid. This is well-nigh proved by the fact that in several of the specimens there are firmly attached to the woolly fibres a few minute pieces of a non-calcareous, solid substance, which is evidently an incrustation, and resembles an incrusting Bryozoön. Around the area of attachment is a circular thickening of the test.

The test resembles the test of Salpa, but is less transparent. On the sides of the body it is about 1 mm. in thickness; on the tentacles it is very thin; in the thickened circle around the base it is 3 mm. thick; on the surface of attachment 1 mm. thick.

The animals are not solitary, but are attached to one another by dorsal and ventral processes of the test and mantle, through the core of which runs a cord of tissue connected with the visceral nucleus. In only two cases in the individuals studied has the union been preserved, but in all the others the broken processes can be seen. The chains must consist of at least four individuals, for each individual of the united pairs shows the broken process which bound it to still another individual. The individuals of a chain are so united that the ventral surface of one is connected with the dorsal surface of the next [Fig. 6 and Fig. 5]. The arrangement of the individuals in the chain corresponds, then, to the arrangement in Pyrosoma and to the primitive arrangement in the Salpa chain. [See Brooks on the anatomy of the Salpa chain in Studies from the Biological Laboratory, J. H. U., Vol. 3]. That the chain was a linear series and not a closed circle, as in Salpa pinnata, is indicated by the fact that three of the better-preserved specimens show but one process. This is not conclusive, because even these specimens are more or less mutilated. There is no inter-circulation between the individuals of the colony, for the processes which unite them are imperforate.

The horizontal septum is as described for O. bithyus, save that I have been unable to find the pits in its upper surface described by Moseley. The arrangement of the muscles of the septum and tentacles agrees with Moseley's description (not with his figures), except that toward the tip of the tentacles the fibres loose their regular ladder-like arrangement and form a delicate mesh work just beneath the test [Fig. 1].

The visceral mass is more elongated than in O. bithyus, extending more or less vertically from the horizontal septum toward the area of attachment [Fig. 5 and Fig. 6, *A*]. Upon one side between the œsophageal and anal apertures is a series of muscles [Fig. 2 and Fig. 6, *A*], differing in arrangement from the similar muscles of O. bithyus. On the opposite side of the visceral mass are a pair of oval perforations [Fig. 3, *cl*]. These connect the so-called peribranchial chamber, not with the digestive tract, but with a space enclosing the viscera, and limited by a delicate membrane which seems to be a continuation of the horizontal septum [see Fig. 5, *pvc*]. This perivisceral space is apparently not in actual connection with the "branchial chamber," since its limiting membrane is united with the horizontal septum around the œsophageal aperture, and the septum itself is fused with the wall of the oesophagus. If we regard the perivisceral space as a diverticulum from the "branchial chamber," now apparently closed, the pair of perforations would have the fundamental character of gill slits, since they unite the peribranchial chamber with what may be considered as a portion of the branchial chamber. That they are phylogenetically related to the gill slits of an ancestral form we have no evidence. From this hurried study I can add nothing else of importance to the descriptions of Moseley and Herdman. I hope to study the material more extensively later and to complete some of the histological details. Upon the condition of the sexual organs I am not yet prepared to report.

Moseley's and Herdman's specimens were very nearly alike, the chief difference being that in one case and not in the other the atrial aperture was borne upon a posterior protuberance, upon whose ventral surface was the area of attachment. Such a slight variation might be due to the nature of the support to which the animal was attached. The Albatross specimens show several marked differences from those previously known. The outer form is very different. The tentacles are not emarginate. The visceral mass is more elongated. Its muscles have a different arrangement. There is a pair of perforations connecting the perivisceral and peribranchial spaces. The individuals are not solitary but are united into a chain. *These differences are sufficient to indicate that the Albatross species is different from Octacnemus bithyus, unless, as seems not improbable, the Albatross specimens are chain individuals and the Challenger specimens the solitary form of the same species.* The apparent relationship of Octacnemus to Salpa, pointed out by Herdman, suggests this interpretation. In the absence of proof of this hypothesis I will, for convenience of reference, give the Albatross specimens the provisional name Octacnemus Patagoniensis.

The diagnosis of the genus will have to be slightly altered to admit this species. I copy Herdman's diagnosis, making the necessary alterations and additions in italics.

OCTACNEMUS, Moseley.

Body flattened antero-posteriorly (?), *or hour-glass shaped, attached,* margins of upper surface prolonged to form eight conical processes (*tentacles*).

Test gelatinous, thin, transparent.

Mantle slight.

Branchial sac with its length directed dorso-ventrally,* *no stigmata in its walls.*

Dorsal Lamina unrepresented.

Alimentary canal united with the reproductive organs to form a visceral mass.

Reproductive organs hermaphrodite (?).

Musculature in the form of narrow muscle bands *present in the tentacles and upon the horizontal septum separating the branchial and peribranchial chambers, also upon the visceral mass.*

OCTACNEMUS BITHYUS, Moseley.

[Abstract of Moseley's and Herdman's description of the distinctive specific characters.]

Body flattened antero-posteriorly (?).

Oral disc saucer shaped, produced into eight emarginate tentacles. Branchial aperture a transverse slit in the oral disc, intermediate between two tentacles. Atrial aperture raised upon a papilla or protuberance, behind the branchial aperture and outside the oral disc.

Horizontal septum having merely imperforate pits, the branchial chamber having no connection with the peribranchial cavity.

Muscles of septum and tentacles as figured [closely agreeing with Fig. 1 accompanying].

Alimentary canal and reproductive organs united into a spherical nucleus.

A mass of muscles on each side of the visceral nucleus and a series of transverse muscles on its dorsal surface between the œsophageal aperture and the anus.

Reproductive organs hermaphrodite.

Two specimens; one from the South Pacific, near Schouten Islands, 1070 fathoms; the other off the coast of Chili, near Valparaiso, 2160 fathoms.

OCTACNEMUS PATAGONIENSIS n. sp. (?)

Body hour-glass shaped, attached by the whole lower surface.

Test and oral disc as in O. bithyus.

Tentacles not emarginate.

Horizontal septum without imperforate pits.

Muscles of septum and tentacles as in O. bithyus, except that at the apex of the tentacles the ladder-like arrangement of the transverse fibres is replaced by a lattice-like arrangement.

Visceral nucleus elongated, the muscles of its dorsal surface showing a characteristic arrangement as figured [Fig. 2 and Fig. 6, *A*].

The viscera are surrounded by a delicate membrane continuous with the horizontal membrane. The perivisceral cavity thus enclosed is connected with the peribranchial chamber by a pair of oval or slit-like orifices ventral to the œsophagus.

The individuals are not solitary, but the ventral surface of one is united to the dorsal surface of the next, forming thus a linear chain comparable to the Salpa stolon.* The uniting processes are imperforate and contain a core of tissue derived from the visceral nucleus.

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*According to Herdman's usage the dorsal surface is that between the branchial and atrial apertures. The ventral surface then is greatly enlarged, extending around nearly the whole animal, from the mouth to the surface of attachment, and up again to the atrial pore. The terms upper, lower and horizontal, may be used with reference to the normal position of the animal in life.

Fig. 1

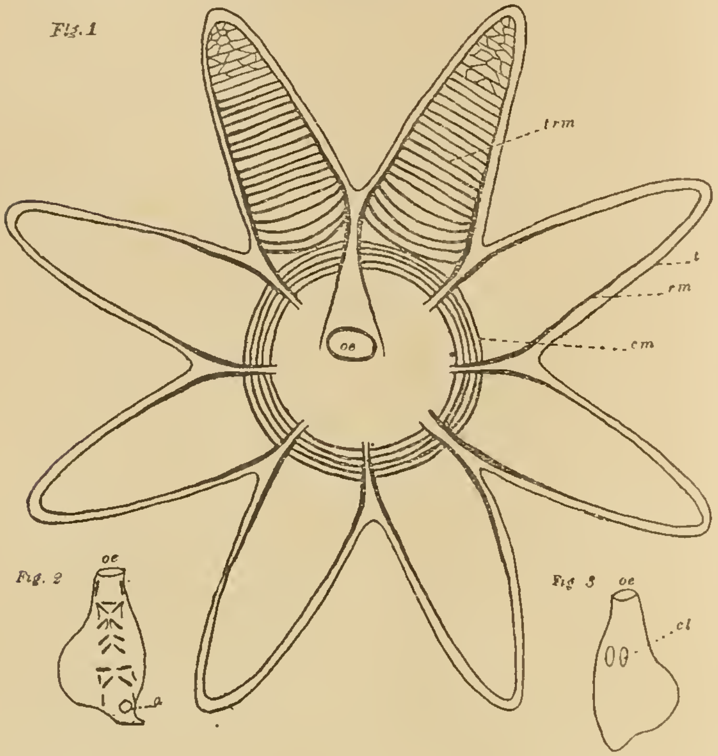


Fig. 2

Fig. 3

Fig. 4

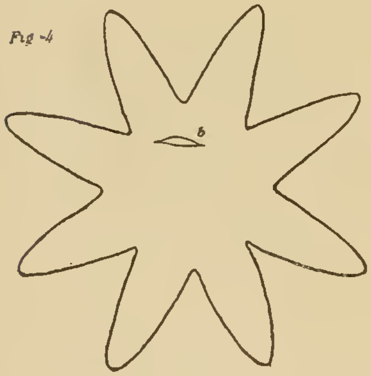


Fig. 5

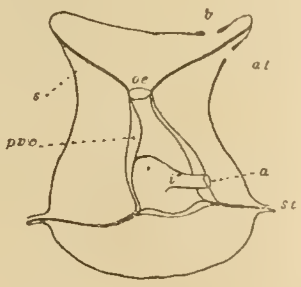
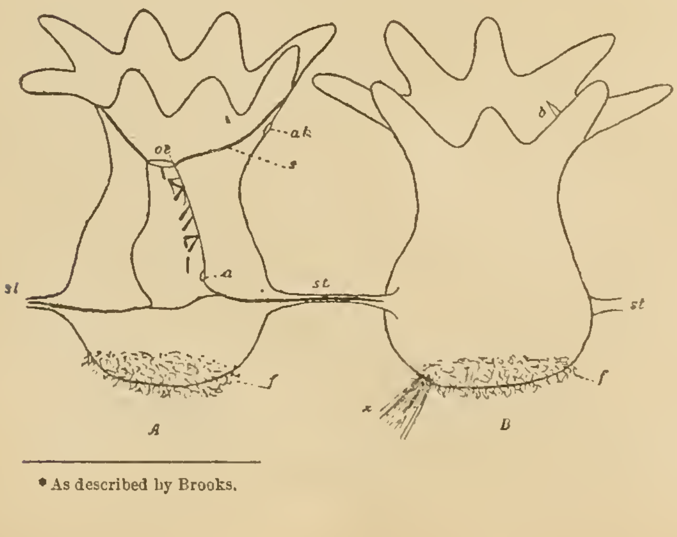


Fig. 6



Several mutilated specimens from the east coast of Patagonia, off Port Oteoay, 1050 fathoms.

Octacnemus Patagoniensis.

Fig. 1. View of the upper surface of the horizontal septum and tentacles, the test and mantle having been removed. The 16 radial muscles (one pair for each tentacle) are shown, also the ladder-like transverse muscles of the tentacles which at the tip of each tentacle form a delicate mesh-work. The circular fibres of the septum are also shown.

Fig. 2. Dorsal view of visceral nucleus showing the arrangement of the muscles.

Fig. 3. Ventral view of the visceral nucleus showing the single pair of clefts connecting the perivisceral and peribranchial cavities.

Fig. 4. View of the upper surface of the oral disk and tentacles.

Fig. 5. Longitudinal vertical section of a detached individual. [The stomach and intestine are drawn in toto.] The section passes through the branchial and atrial aperture, therefore, between the tentacles. The cords of cells running out from the visceral nucleus into each stolon are shown.

Fig. 6. Side view of two individuals united by a stolon: *A* drawn as if the test and mantle were transparent: *B* drawn as if the test were opaque.

Reference Letters.

a = anus.
at = atrial aperture.
b = branchial aperture.
cl = clefts connecting the perivisceral and peribranchial cavities.
cm = circular muscles of septum.
f = fibres by which the animals were attached to the bottom.
i = intestine.
œ = œsophageal aperture.
pvc = perivisceral cavity.
rm = radial muscle.
s = horizontal septum between branchial and peribranchial chambers.
st = stolon.
t = external contour of test.
trm = transverse muscles of tentacle.
x = delicate fibres of unknown nature observed in one specimen.

Preliminary Notes on the Stomatopoda of the Albatross Collections and on other Specimens in the National Museum. By R. P. Bigelow.

(Published by permission of the U. S. Commissioner of Fish and Fisheries.)

In a former paper* I published descriptions of the five species of Squilla of which I had a good supply of material. These were *Squilla armata*, Milne-Edwards, and four new species, *S. potila*, *parva*, *Panamensis*, and *biformis*. I now wish to present a short preliminary account of the other forms in the collection.

Genus *Gonodactylus.*

This genus as defined by Miers included all those species in which the raptorial claw is without pectinations on the penultimate joint, and has the dactylus dilated at the base. Brooks has separated from this the genus *Protosquilla*, forms having the dactylus unarmed and the telson fused with the sixth abdominal segment, and the genus *Coronida* having the hind body depressed, the dactylus armed with spines on the inner edge, and possessing very small antennary scales and uropods. The forms that now remain in the genus Gonodactylus naturally fall into two groups, one clustered around the well known *G. chiragra*, Latr., and the other around *G. scyllarus*, Linn. These two groups are so distinct that they might perhaps be given the rank of genera. I shall describe them provisionally as subgenera. The first, *Gonodactylus*, proper, corresponds exactly to Brooks' definition of the genus; the hind body is convex, the dactylus is enlarged at the base and is unarmed, and the rostrum has a prominent anterior median spine. The other subgenus, for which I propose the name Odontodactylus, has a somewhat less degree of convexity in the hind body, the dactylus is dilated at its base but it is also armed with teeth on its inner edge, and the rostrum, while more or less triangular, is never produced into a spine. The telson is also quite different in the two subgenera. In the first the dorsal carinae are grouped together (on a central elevation with the median crest); while in the second the arrangement of the carinae and the telson in general resembles very closely what is found in Pseudosquilla. There is no marked elevation at the centre of the telson, other than the crest.

Most of the specimens of this genus in the collection are of the common species *G. chiragra*, Latreille. There are a large number of these from the

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* As described by Brooks.

* *Johns Hopkins University Circulars*, No. 88, May, 1891.

Florida Keys, the Gulf of California and the Abrolpos Islands. Besides these I find two new species, one belonging to each of the subgenera.

Gonodactylus spinosus, n. sp.

This species corresponds in structure almost exactly with *G. chiragra*, except for the telson, which presents striking and characteristic differences, In *G. chiragra* the lateral marginal spines of the telson are obsolete, so that there appear at first sight to be but four marginal spines. In this species the intermediate pair have also become obsolete, so that the telson appears to have but a single pair of marginal spines, the submedian. They have small movable tips. There are three central dorsal prominences, higher and more closely pressed together than in *G. chiragra*. The basal carinae of the submedian and intermediate marginal spines are represented by broad, rounded, longitudinal prominences, separated from each other and from the central ones by narrow grooves, and the whole dorsal surface, except the bottoms of the grooves is rendered prickly by numerous minute projecting spines. The collection contains two small female specimens from Mauritius.

Gonodactylus Havanensis, n. sp.

This species is represented by a single small specimen from the Gulf of Mexico, near Havana. The body is short and broad and not very strongly arched. The dactylus of the raptorial claw is of the usual shape for this genus but its cutting edge is produced into a series of six small teeth besides the terminal one. The eyes are very large and subspherical. The antennary scale is large. The carapace is smooth and nearly square with rounded angles. The sixth abdominal segment has six dorsal spines. The telson resembles that of a Pseudosquilla. It has a median crest and four other carinae upon its dorsal surface. There are six marginal spines, the submedian ones with mobile tips longer than in *G. scyllarus*. There are numerous very minute submedian denticles, two intermediate ones of the usual size and one lateral one. The basal prolongation of the uropod ends in two simple spines, the outer one being the longer but not so long as the exopodite.

This specimen is remarkable in that while being a male it lacks the usual clasping organs on the first pair of abdominal appendages which are just like those of a female. This may be an abnormality.

Genus *Pseudosquilla*.

P. ciliata, Miers, is represented by a large number of specimens from the Florida Keys and one specimen from Honolulu (?). There is a single specimen of *P. ornata*, Miers, from Mauritius, one of *P. oculata*, Brullé, from the same place, and one of *P. Lessonii*, Guerin, collected by the Albatross at Station "Surf. 29" of which I have been unable to learn the locality. I might mention also that there is in the collection of the Johns Hopkins University a specimen of the peculiar *P. stylifera*, Milne-Edwards, which should probably be placed in a genus by itself. In addition to these I have to add to the list a new species from Mauritius:

Pseudosquilla megalophthalma n. sp.

As is indicated by its name, this species is distinguished from all others by the size of its eyes which are very large and triangular with the corneal portion transverse. It is related to *P. ornata* and *oculata*, perhaps more closely to the latter, but it is at once distinguished by its eyes. The raptorial claw is very long and slender and the dactylus has three teeth. The rostrum is nearly heart shaped and without spines. The sixth abdominal segment bears the usual six dorsal spines and there is a small additional spine on the inner side of each intermediate one. The telson has six marginal spines and like *P. oculata* has eight dorsal carinae besides the median crest and the basal carinae of the submedian and intermediate spines. But the carinae are arranged differently in the two species.

Genus *Lysiosquilla*.

A single specimen of *L. maculata*, Fabr. from the Marquesas Islands and a few specimens of *L. scabricauda*, Lam. from the Florida Keys are the sole representatives of this genus.

Genus *Squilla*.

Squilla quadridens, n. sp.

The eyes are small but triangular with the cornea somewhat oblique. The dactylus of the raptorial claw is short and has four teeth including the terminal one. The rostrum is nearly flat and ovate. There are no carinae on the carapace except on the posterior lateral lobes and there are no submedian carinae on the hind body except on the sixth abdominal segment. The anterior lateral angles of the carapace are nearly right angles and are subacute, and the posterior lobes are rounded. The lateral margins of the first exposed thoracic segment are very short and acute while those of the next two segments are broadly rounded. The dorsal surface of the telson is provided with a low crest ending in a spine and with a series of shallow, symmetrically curved furrows. The ventral surface is smooth without a keel. There are six marginal spines, of which the submedian pair have mobile tips, and there are on each side 4–5 submedian denticles, 6–8 intermediate ones and 1 lateral one. There are 4–5 movable spines on the outer edge of the uropod, and its basal prolongation has six long slender teeth on its inner edge and ends in two spines. The inner one of them bears a large rounded lobe on its outer edge.

I have ventured to found this species upon a single small specimen from off Key Largo, Florida, although it is very similar to the Californian species *S. polita*, Bigelow, for by comparing two specimens of the same size it was seen that the latter differs from the former in having the thoracic segments much narrower and the lateral margins of the first segment broad, curved slightly forward, and blunt, in having larger eyes and a ventral keel on the telson.

Squilla dubia, Milne-Edwards.

Specimens of this species have so far been recorded only from the eastern coast of the American continent, but I have before me a specimen from Ecuador that seems to belong to this species.

Squilla prasinolineata, (Dana?) Miers.

A specimen in the collection from an unrecorded locality corresponds pretty closely to Miers' description.

Squilla mantoidea n. sp.

From the descriptions one might be lead to suppose this species to be almost identical with *S. mantis*, DeGeer, but a comparison of specimens shows them to be quite different. The eyes are triangular, but the cornea is transverse. The dactylus of the raptorial claws has six teeth and its outer margin is not sinnate. The rostrum is subquadrate and carinated. The carapace has five carinae and strongly developed anterior lateral spines. The median carina is bifurcated. The marginal spine of the first exposed thoracic segment is short, straight and acute, but, unlike *S. mantis*, is flattened obliquely. The margins of the next two segments are strongly produced and acute. The submedian carinae on the hind body are without spines, except on the sixth abdominal segment. The telson has a dorsal crest with twelve or more lines of pits on each side and it has a long ventral keel, six marginal spines, and on each side 5–6 submedian denticles, 11–12 intermediate and 1 lateral one.

I have a single female specimen from Borneo.

Squilla aculeata, n. sp.

The species to which I have given the above name on account of the enormous marginal spines on the telson of the male, is rather more closely related to *S. mantis* than the previous one.

The eyes are small but triangular with the cornea nearly transverse. The dactylus of the raptorial claw is very strong, has six teeth, and is not sinuate in its outer margin. The rostrum is broad and has marginal and median carinae. There are five carinae on the carapace and eight carinae on the first five abdominal segments. The carapace has anterior lateral spines and the posterior lobes are angled at the sides. The lateral spines of the first exposed thoracic segment are curved forward and acute, and the margins of the second and third are acuminate. In the male there is a thickened crest on the telson ending in a small spine and the surface of the telson on each side is marked by curved lines of pits. There are six marginal spines. The submedian and intermedian pairs are very large and are curved, and like the lateral ones have thickened basal carinae. The denticles on each side are 3–4 submedian, 5–7 intermediate, and 1 lateral. There is no trace of a ventral keel. The inner spine of the basal prolongation of the uropod is much longer than the outer, and has a rounded lobe on its outer side near the base.

I have a single male specimen from Iqueque, Chili, and what I take to be an immature female from Panama. In the latter the crest and spines of the telson are not thickened nor unusually developed. It agrees with the male in most other points, although it approaches the next species.

Squilla empusa, Say.

Comparison of specimens shows so slight a difference between this species and the European *S. mantis* that I should regard it, as Meirs has suggested, as merely a variety of the latter. The National Museum contains specimens from numerous localities between Woods Holl, Mass., and Pensacola, Fla.

Squilla intermedia, n. sp.

This species is represented by a male from the Gulf of Mexico and a female from the Bahamas, and occupies an intermediate position between two species from the Pacific, described in my earlier paper, *S. Panamensis* and *biformis*. The telson of the female resembles that of the female *S. biformis*, but differs from it in having larger and fewer denticles (4–6, 10–13, and 1), larger marginal spines, a higher crest, and a short ventral keel without a spine. In the male the crest and the margin of the telson is much thickened on the dorsal side, but it differs from the male of *S. biformis* in having two interruptions in the marginal ridge on each side. One of these marks the end of the anterior lateral carina and the other is just behind the lateral denticle. Except for these the ridge is smooth and continuous. The lateral margins of the first exposed thoracic segment is produced into strongly sickle-shaped acute spines, and the margins of the next two segments are obliquely truncated and very acute.

Squilla nepa, Latreille.

Squilla affinis, Berthold.

I find that the specimens in the National Museum that correspond to Miers' description of *S. nepa* may be divided into two distinct species. One of these has small eyes with transverse corneae, the dactylus of the raptorial claw strongly sinuate on its outer margin, the median carinae of the carapace bifurcated for nearly or more than half its length and the spines of the anterior lateral angles extending farther forward than the suture between the carapace and the rostrum. The other group has large eyes with oblique corneae, the outer margin of the dactylus not sinuate or only slightly so, the median carina of the carapace not bifurcated for more than a quarter of its length, and anterior lateral spines which do not reach so far forward as the suture between the carapace and the rostrum. The question immediately arises, which is the form that was originally described as *S. nepa*, and has the other form been described? A search of the literature shows that Berthold* was the first to separate these two forms. He correctly assigned the small-eyed one to Latreille's species *S. nepa* and he carefully described the large-eyed one and gave it the name *S. affinis*. A few years later De Haan published a short description of this species in Latin and renamed it *S. oratoria*, but Berthold's name should have the priority.

Squilla rugosa, n. sp.

The first impression one receives on handling a specimen of this species is the marked prominence and sharpness of all its carinae and spines. The eyes are large and triangular with the cornea oblique. The raptorial claws are long and the dactyli are armed with six teeth. The carapace has five carinae, the median one is not bifurcated in front. The posterior lobes are rounded and the anterior lateral angles are acute. There are submedian carinae on all the segments of the hind body. The marginal spines of the first exposed thoracic segment are lanceolate and acute while the lateral margins of the next two segments are rounded in front and are produced behind into a spine that points directly backward. There are three or four teeth on the posterior margins of the fifth and sixth abdominal segments between the submedian and intermediate spines. The dorsal surface of the telson is ornamented with ten prominent carinae on each side of the crest. There are six marginal spines, and the denticles on each side are 5 submedian, 10–12 intermediate, and 1 lateral. The basal prolongation of the uropod ends in two spines and has 8–12 long teeth on its inner margin. The inner spine has a rounded lobe on its outer side.

I have a single female from the Gulf of Mexico, off Charlotte Harbor.

LARVAE.

The most marked features of the collection of larvae are a number of large Lysiocrichthi from the Atlantic, resembling Brooks' Fig. 7, Pl. X,* and a number of very large Alimae from the Bay of Panama. These have a broad carapace. The only larval forms of especial interest are a few specimens from the Atlantic that appear to be Gonerichthi, but which show traces of marginal teeth on the dactylus of the raptorial claw beneath the larval integument. One of these resembles Brooks' Fig. 5, Pl. XII, but the body is more elongated, approaching the type of Pseuderichthus. It has seven teeth on the dactylus besides the terminal one. The other form is much shorter and broader, and the carapace nearly equals half of the length of the body. There are five teeth on the dactylus besides the terminal one. It seems probable that these are Gonodactylus larvae of the subgenus Odontodactylus. They will be described in detail in the final report.

The Stomatopoda of Bimini. By R. P. BIGELOW.

It was my good fortune to be one of the party sent out by this University last summer to the Bimini Islands, in the Bahamas. Without making an especial effort, we found at Bimini adults of four species of Stomatopods, belonging to as many genera. Two of these species, *Gonodactylus chiragra*, Latr., and *Pseudosquilla ciliata*, Miers, were abundant on the sand flats, hiding among the algae and under shells and stones. We did not find any burrows of Gonodactylus in the rock, such as were found at Green Turtle Cay, but, on the other hand, we discovered a number of specimens of this species within the cavities of the red sponge, so common at Bimini. The coloring of these two stomatopods varies greatly, but in the same way. Their habits are also alike, so that they are difficult to distinguish when seen moving rapidly over their native sands. The coloring is distinctly protective, varying from a mottled green and white to a nearly pure green. Occasionally a Pseudosquilla is met with that has a broad longitudinal stripe of green along the middle of its back while its sides are mottled.

Of the other two species, one is a Lysiosquilla of the subgenus Coronis, and the other is a Squilla. Both were found burrowing in the sand. It is a remarkable fact that both of these species are very similar to species from the Australian region. It is possible, indeed, that they are identical, but from the descriptions this does not seem to be the case, and I therefore describe the forms from Bimini as new species.

Lysiosquilla Biminiensis, n. sp.

The most striking peculiarity of this species is the possession of bright yellow markings bordered by deep black. There is a double band of this sort edging the margin of the posterior lobes of the carapace and the lateral parts of the posterior margins of the last thoracic and the fifth abdominal segments. The telson has also a pair of black eye spots edged in front with yellow. The ground color of the body is an opaque white, and this is marked by transverse bands, one on the rostrum, two or three on the carapace, and one on each of the free segments. On one of my specimens, a male, these bands were fawn colored; while on the other, a female, they were pink. In addition to the fawn color or pink, the band was marked by fine dark, reddish-brown stipplings.

The eyes of this species are cylindrical. The dactylus of the raptorial claw has six teeth including the terminal one which is the strongest. The appendages on the first two pair of pleopods are broadly ovate, while they are strap-shaped on the third pair. The rostrum is nearly quadrate with a median spine and the carapace is smooth and without angles. The angles of the segments of the hind body are rounded, except the posterior lateral angles of the sixth abdominal segment which are produced into spines. The telson has a transverse row of five dorsal spines, and it has six marginal spines; besides these there are on each side of the median line, 3–4 submedian denticles, 4 intermediate ones and one lateral one. The submedian marginal spines are placed somewhat ventrally and are mobile. This species is most nearly related to *L. acanthocarpus*, Miers, which differs from it in having on the raptorial dactylus a spine next to the terminal one much smaller than the rest, in having twelve *minute* submedian denticles on the telson, and it is probable that it also lacks the striking coloring of our species, as Miers makes no mention of it.

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* Abhandl. d. kön. Ges. d. Wiss. zu Göttingen, 3 Bd, 1845.

* Voyage of H. M. S. Challenger, Vol. XVI, 1886.

Squilla alba, n. sp.

The color of this species is likewise a characteristic feature. Except for the corneal region of the eyes which is yellowish, the whole animal is a pure opaque white marked by only a few symmetrically and definitely placed minute black spots. The shape of the animal is also peculiar. The carapace and the exposed portion of the thorax are equal in length, and together make up about four-ninths of the total length of the body. The segments in front of the carapace are elongated so that the rostrum does not completely cover the first antennary segment, and the eyes are unusually large so that the whole cephalothoracic region has a drawn out appearance.

The raptorial claw is large and its dactylus has six teeth. The rostrum is ovate with obsolete carinae. The carapace has five carinae. The median one is not bifurcated in front but stops short some distance behind the anterior edge of the carapace. The anterior lateral angles of the carapace are produced into spines and the posterior lateral angles are rounded and do not form unusually prominent lobes. The first exposed thoracic segment has no ventral spines but on each side there are two lateral lobes, the anterior one being large, strongly curved forward and acute, while the posterior one is short and rounded. This character shows a relationship to *Squilla nepa*, but the lateral margins of the next two segments are not bilobed as in that species but are simply rounded. There are eight carinae on the first five abdominal segments. The telson is nearly smooth with a low crest ending in a spine and a few curved lines of confluent pits upon its dorsal surface. It has six marginal spines and on each side there are 5–6 submedian denticles, 12 intermediate ones and 1 lateral one. There is a large rounded lobe on the inner tooth of the basal prolongation of the uropod and another one in the angle between the two teeth.

Miers has placed *Squilla laevis*, Hess, among the synonyms of *S. nepa*, Latr., but de Man would separate the two; for, according to him, *S. laevis* has no median carina on the rostrum, the lateral margins of the second and third exposed segments are not bilobed and the posterior angles of the carapace are not simply rounded but project into a rather prominent lobe. Although this species inhabits the seas of Tasmania and New Zealand, it may possibly prove to be identical with my species.

Larvae.

A few Stomatopod larvae of various kinds in various stages were met with from time to time, but after dark on the evenings of July 19th, 20th and 21st the tow nets were crowded with very small Gonerichthi, apparently identical with that represented by Claus[*] in his Fig. 22 B.

Among the larvae less frequently seen there were a few specimens of an elongated Alima with a small and very narrow carapace. One of these moulted in the aquarium and emerged from the larval skin as a young Squilla which, while differing somewhat from the type, agrees so closely with *Squilla quadridens*, described by me on page 101, that I have no hesitation in placing it in that species.

A more complete account of the forms mentioned in this paper will be introduced into my report on the Stomatopods of the Albatross.

Cement-Glands, and Origin of Egg-Membranes in the Lobster.

By Francis H. Herrick, of Adelbert College.

The cement-glands have hitherto escaped detection in the lobster (*Homarus americanus*), and consequently the origin of the gluey secretion, in which the eggs are immersed at the time they are laid, and by means of which they are attached to the body, has never been accurately determined.

Cano's valuable studies (*Morfologia dell'appareccio sessuale feminile, glandole del cemento e fecondazione nei Crostacei Decapodi, Mittheil. Neapel, 9th Bd.*) have called attention to the much neglected cement-glands of the Decapod Crustacea.

Erdl, in 1843, described three egg-membranes in the egg of the lobster, and regarded the outermost of these as a secretion-product of the oviduct. Bumpus, also (*Journal of Morphology*, Vol. V, No. 2), attributes the "varnish-like layer," which surrounds the ovum of Homarus at the time of oviposition, to a secretion, which probably comes from the columnar cells of the oviduct. Lereboullet just escaped the discovery of the cement-glands in 1860, but correctly stated that the cement-substance came from beneath the skin of the under side of the abdomen. The true cause of this secretion was first recognized by Braun in 1875, and the subject has been recently investigated in a large number of Decapods with great clearness by Cano.

When the lobster-embryo is about to hatch, it is invested by three membranes, from which it escapes to enter upon its first free-swimming larval stage. The outermost of these is the membrane of attachment. Within this is the chorion, which is now nearly absorbed. This is exceedingly delicate, and is often carried away with the former in the process of hatching. The innermost membrane does not belong to the egg, but to the embryo, which it closely invests. The casting off of this membrane forms the first molt, and unless it is successfully thrown off, the larva dies. The earlier embryonic cuticles, which are formed in the long course of embryonic life, are entirely absorbed at the time of hatching.

The secondary egg-membrane, or membrane of attachment, completely separates from the chorion at the time of hatching, except at one point, which is often opposite the thread-like stalk, with which the outer capsule of the egg is continuous. The outer membrane, which is less elastic than the chorion, is subjected to a high degree of tension, until it finally bursts, splitting into two symmetrical halves, along the vertical longitudinal plane of the body of the embryo, beginning at the hinder end, and coming off over the head and tip of the abdomen.

When the chorion or primary egg-membrane is removed from the ripe egg by means of hot water, it appears to be covered with small, rounded areas, which are possibly the impressions of the follicular cells. No distinct pores could be detected in it, but when wrinkled it appears to be vertically striated, which may argue in favor of their presence.

For some time before oviposition, the pleopods appear to be filled with a milky white substance. This appearance is caused by the distended condition of the cement-glands, to the activity of which the secretion which forms the secondary egg-membrane is due. If the cuticle is removed from a pleopod at this time, the tissue is seen to be studded with very minute, round, whitish bodies, the cement-glands. They are most abundant over the posteriorly directed sides of the laminae, and extend up into the stalk. It is noticed also, in a lobster "in berry," that it is upon this side of the smimmeret that the eggs are mostly attached. I have found the glands in the five anterior pairs of pleopods only, but it is possible that they may occur in the telson, the uropods, and epimeral regions. The glands occur singly or in clusters, and are closely crowded along the thickened edges of the laminae.

Sections show that the gland is composed of a very delicate sheath of connective tissue, and a simple epithelium consisting of tall, pyramidal cells. The polygonal base of each cell occupies the periphery, at which a large round nucleus is situated, and the apices of the cells meet near the centre of the gland, the lumen of the organ being at this time very slight. It is almost impossible to detect, in sections, the opening of the gland to the exterior, but it is quite probable that each gland opens separately. Cano describes these glands in numerous forms as bottle-shaped structures, the necks or ducts of which open to the exterior through pores in the cuticle. Pores can be shown to exist in the lamina of the pleopod, by removing the tissue by caustic potash, and distending the cuticle with water, but pores of the same kind also exist in the appendages of the male, where no cement-glands occur. I cannot, at present, say how the pores are distributed on the surface of the cuticle, but it is probable that they are not confined to any particular area.

If the glands are examined shortly after oviposition, they show a remarkable change in structure. The glands are enlarged, and the epithelial cells have the appearance of degeneration, their nuclei presenting every stage of fragmentation from the condition of minute chromatin-particles, which fill almost the entire gland, to deeply stained, round, granular masses, which are much larger than ordinary nuclei. Under these conditions cell-outlines are very dim, and the lumen of the gland is not open.

It seems quite probable that the peculiar gland-like structures, which I have described in the immature ovary of the lobster (See these *Circulars*, No. 88), are concerned with the growth of the ovarian eggs. Numerous follicular cells enter these growing ova at an early stage, and gradually become converted into food-products. Their nuclei break up into very small vesicles, and finally lose all their nuclear characteristics, when their degeneration is complete.

Cleveland, Ohio, March 21st, 1893.

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[*] Abhandl. d. k. kön. Ges. d. Wiss. zu Göttingen, 16 Bd., 1871.

Podopsis a Larva of Stenopus. By Francis H. Herrick, of Adelbert College.

A new genus of "Shizopodae" was described and figured under the name of "Podopsis," or Hammer-headed Shrimp, by J. V. Thompson in 1829.* "This Genus," he says, "remarkable for the great length of the Footstalks on which its large and spreading Eyes are placed, ... was discovered in that region of the Atlantic frequented by the Nocticula, being captured in N. Lat. 29° 30′, W. Long. 32° 55′, on the 25th September, where it contributes its share to the luminosity of the sea. . . . It is perfectly diaphanous and colorless, and although its members were not particularly scrutinized, it is undoubtedly a natatory Shizopoda."

An examination of his drawing (Pl. VII, Fig. 1), which represents a dorsal view of this form, several times enlarged, together with his very brief remarks, leave little doubt that Podopsis is not an adult at all, but a *larva* of Stenopus, and probably a larva of *Stenopus hispidus.*

On the same plate with Podopsis, there appears a figure of Lucifer, a form which has become a classic among the Crustacea, but I have been unable to find a single allusion to Podopsis in the literature which is accessible to me. I was unfamiliar with this paper when studying Stenopus, a sketch of which was published last fall. (See Memoirs of Nat. Acad. of Sciences, Vol. V, Fourth Memoir; The Embryology and Metamorphosis of the Macroura, Chap. II; The Life History of Stenopus, Washington, 1892.) In this account of Stenopus, seven larvae are described. Two were raised from the egg of Stenopus hispidus, at Nassau, New Providence; two were obtained in the tow-net by Professor Brooks, at Beaufort, North Carolina, and presumably belong to this species, but this could not be definitely settled. Two others were taken at the surface outside the harbor at Nassau, and are designated in my paper as "Mastigopus" stages "E" and "G." Larva "E" moulted, while in captivity, into a slightly different stage, designated as larva "F."

The form figured by Thompson is strikingly like the Stenopus-larva represented on plate XII of my paper. This larva measures 9 millimeters from rostrum to telson, and is evidently older by several molts than the stage which came into Thompson's net. Thompson's larva corresponds more nearly with larva "E," although it is considerably larger, if the small drawing on Thompson's plate, designed to show the natural size, is accurate. This drawing measures about 10 millimeters. The size, however, of older crustacean larvae is subject to great variation.

The antennae of larva "E" are thus described in the paper on Stenopus, referred to. "Both pairs of antennae are biramous. The outer flagellum of the first or inner pair is the longest . . . . The inner branch is a bud. The second antennae extend as far forward as the joint of the first pair, where the inner flagellum is given off. The flagellum of the second pair is wound into a short spiral coil." In describing the antennae of "Podopsis" Thompson says: "Near to the insertion of the footstalks of the Eyes, are two short appendages, which are probably the rudiments of the upper antennae." These "short appendages" are undoubtedly the rudiments of the flagella of the second pair of antennae, which are described in Stenopus-larva "E." Judging from the condition of the antennae, this larva is older by one moult than the stage figured by Tompson.

In the enormous eyestalks, the antennae, the huge size of the third pair of maxillipeds, the configuration of the body and of the tail-fin, there is a very close agreement between Podopsis and the Mastigopus larval stages of Stenopus hispidus.

The pereiopods are not figured or described by Thompson, so that no comparisons of these important appendages can be made. In Stenopus-larva "E," the fourth pereiopod is a two-jointed rudiment, and the fifth pereiopod is reduced to a bud.

In Podopsis, the first three pairs of pleopods are described and figured as uniramous, and the fourth and fifth pairs as biramous. This distinction was not noticed in the Stenopus larvae. In larva "F," into which larva "E" moulted, all the abdominal appendages were uniramous. Without being able to make accurate comparisons in this particular, the remarkable agreements already pointed out, lend sufficient weight to the conclusion that "Podopsis" is one of the Mastigopus-larvae of Stenopus.

Adelbert College, Cleveland, Ohio, March 17th, 1893.

The Bahama Amphioxus. By E. A. Andrews.

In addition to the amphioxus, or lancelet, found on the coasts of many parts of Europe, some five others have been reported from various parts of the world. Guenther recognizes these six as species of Branchiostoma, that name having been given prior to the term Amphioxus. The chief specific characters that can be made out in the preserved specimens are the relative positions of anus and atriopore as expressed by the number of muscle segments anterior to, between and posterior to these openings. In addition to these forms there is an undescribed lancelet in California, which, as far as the above criteria may be trusted, belongs to a distinct species of Branchiostoma, and a Japanese form that may prove to be one of the known species.

The great morphological interest attached to the lancelet as the simplest, and in many respects, the most primitive, of known vertebrates makes the taxonomy and geographical distribution of this group of more than common importance and justifies a short preliminary account of a new form found in the Bahamas.

While the Johns Hopkins Marine Laboratory was stationed at North Bimini, Bahamas, in the summer of 1892, many small lancelets were taken swimming at or near the surface as well as living in the calcareous sand on the flats exposed at low water.

These partly pelagic acraniates differ so much from the known forms that they may be regarded as *generically* distinct. Their chief anatomical peculiarities are as follows:

(1) The gonads are developed only upon the right side of the body, both in the adult and in the young.

(2) The notochord, neural tube and median fins are prolonged as a considerable caudal process posterior to the myotomes.

(3) The ventral fin is without any fin-rays or successive fin-ray chambers.

(4) The pre-oral hood is extensive: cirri smooth and united by the hood membrane for the greater part of their length.

(5) The right metapleuron is continuous with the median, ventral fin, which passes to the right of the anus.

(6) The "olfactory pit" is apparently absent.

(7) Myotomes anterior to atriopore 44; between atriopore and anus 9; posterior to anus 13: total, 66. Length, 13–16 mm.

(8) Swims free in the evening both at Bimini and in Nassau Harbor. Lives also in the calcareous sand.

An illustrated description of these characters of this new genus of acraniates will appear in a forthcoming number of Vol. V of the Studies from the Biological Laboratory.

The Food Supply of the Adult Oyster, Soft Clam, Clam and Mussel. By John P. Lotsy.

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During the summer of 1892 I made a series of experiments to determine the nature of the food of the oysters found in the James River.

The results of the work are given here only in brief, fuller particulars being reserved to appear in my report, which will be published by the Fish Commission.

The methods pursued in the investigation were briefly as follows: The gills of the oyster were separated by means of a sharp scalpel, so that the oral opening was exposed. Into this a pipette was introduced, and the contents of the stomach were sucked out. When examined under the microscope the material thus obtained showed the presence of numerous Diatoms together with about an equal quantity of decaying organic matter and sand. With the exception of a very few of the lower forms, such as Rhizopods, Euglena, etc., which were occasionally seen, animal life was practically absent. Especially noteworthy was the entire absence of Copopods, although these were very abundant in the surrounding water.

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*The title of this paper is "Zoölogical Researches, and Illustrations of Natural History of Nondescript or imperfectly known Animals, in a series of Memoirs: Illustrated by numerous Figures. By John V. Thompson." Memoir III: On the Luminosity of the Ocean; with descriptions of some remarkable species of luminous animals (Pyrosoma pigmaea and Sapphirina indicator) and particularly of four new genera, Nocticula, Cynthia, Lucifer and Podopsis, of the Shizopodae; with four plates. With Addenda. No. II, pp. 37-68; Pls. V-VIII. Cork, April, 1829.

The presence of the Diatoms in such numbers in the stomach of the oyster, although it by no means absolutely proved that they were utilized for food, furnished a suggestion for further study. Observation has taught us that the oyster is constantly ingesting a stream of water, and until the contrary has been shown it seems not unreasonable to suppose that every object within the power of this stream will find its way into the stomach.

To prove that anything found in the stomach serves as food it is necessary to show that the object furnishes a possible source of nutrition, and also that this digestible matter becomes dissolved on its way through the intestinal canal. In the case of the Diatoms this last point was very easy to determine since their membranes, owing to the silica which they contain, are wholly indigestible. To ascertain whether the Diatoms were actually digested it was necessary to collect and examine the excreta. I may here say that all which follows applies equally well to clams, soft clams and mussels, the nutrition of which was investigated at the same time. In order to obtain the excreta a number of oysters were placed separately in glass dishes, which had been filled with strained sea water, their shells having been previously cleaned carefully with a brush. After a few hours an abundance of faeces was found deposited in the dishes. This was collected from all the dishes, rubbed up with water, and from the mixture a sample was taken for examination under the microscope. From twenty-five fields which were counted the results showed that 96 per cent. of the Diatoms had lost their soft parts entirely, 3 per cent. almost entirely, and only 1 per cent. remained undigested. The decaying organic matter was apparently unaltered.

The question remained to be solved why the Copopods and other animal forms which were abundantly present in the surrounding water were absent from the stomachs of the oysters and other bivalves. The most natural supposition to account for this is that which assumes a power of discrimination on the part of the bivalves. To test this assumption the following experiments were made: Cultures of Diatoms were obtained after a method which is given in full in the report. Since Copopods could not be readily obtained, fine hashes were made, one of fish and one of shrimps, the chief point being of course to decide whether the bivalves had any discriminating power at all. A quantity of the Diatom culture sufficient to cause a slight cloudiness in the water was brought by means of a glass tube close to the ventral opening of the sipho of a clam. The little cloud was immediately ingested. Many cultures given in this way would be accepted by a single individual. The same experiment was then tried, using the hashes of fish or shrimps in the form of a similar cloudy suspension in water, but in this case the result was strikingly different. The suspension was either not accepted at all, the sipho closing immediately as soon as it came in contact with it, or if ingested it was forcibly rejected an instant later, being often thrown to a distance of six or seven inches. Exactly the same took place in the case of soft clams, and the same phenomena were observed if such cultures or suspensions were brought between the opened shells of the oyster.

The last part of the report gives a simple method of staining small organisms. The conclusions are:

The food of the adult oyster consists practically of Diatoms.

The oyster possesses the power of discriminating between different kinds of food offered to it.

On the Toxic Substances of the Bacillus Amylivorus, the Cause of Pearblight. A Preliminary Notice by John P. Lotsy.

It occurred to me some time ago that it would be of considerable interest to determine whether or not the lesions in the bacterial diseases in plants were, like those in animals, caused by the toxines secreted by the parasite. It is of course conceivable that in plants other causes might bring about the death of the cells; thus for example the cell-death might result perhaps from a destruction of the cellulose skeleton or from a plugging up of cells in such a way as to hamper the transpiration stream. If this was the case death would be, so to speak, a secondary occurrence. A culture of the bacillus of pearblight was obtained from the pathological laboratory of the Johns Hopkins University, and its virulence tested by inoculation into two varieties of pears, one said to be very susceptible to infection, the other to be naturally immune against it. In accordance with Russell's results it was found that this immunity disappeared on experimental infection. A culture of the bacillus was now made in plain potato-bouillon. The bouillon was not neutralized, the idea being to have the bacillus grow under as nearly the same conditions of acidity as it meets with in nature. The culture was allowed to grow for three weeks, and after this time without previous heating the bouillon was filtered through a Pasteur-Chamberland filter. Small sterilised test-tubes were partially filled with the fluid thus obtained and subsequently plugged, all chances of contamination being avoided. Cuttings of the two varieties of pears taken from twigs of this year's growth in the hothouse were introduced through the cottonplug into the fluid of ten of these tubes. In two other tubes of plain bouillon without bacterial products similar cuttings were inserted as controls. It was hoped that by this method of experiment the toxines present might be carried along by the transpiration stream. The tubes after being prepared in this way were buried nearly up to their mouths in a pot of sand in the hothouse. After eight days all ten cuttings placed in the tubes in which the toxine was present showed the characteristic features of pearblight, while the cuttings in the two control tubes remained perfectly healthy. The microscopic examination proved that no bacteria were present in the tissue, and showed that in regular longitudinal rows of cells the protoplasmic contents were dead, brownish in color and shriveled. More experiments, especially with the pure toxine, are in progress, and concerning these and the finer histological changes I hope to report before long. Special thanks are due to Dr. B. W. Barton for the kindness with which he offered the use of his hothouse for these experiments.

Baltimore, April 18, 1893.

Note on the Origin of the Tetrasporangia in Dasya elegans. By B. W. Barton.

The material for the present work was kindly furnished by Dr. Lotsy, who collected it at Bridgeport, Conn., in December 1892 during the cold days of that month when the temperature of the water stood at 0° C. At this period plants bearing antherids and procarps are not found.

The asexual propagative spores are so formed by quadrate or cruciate division of the mother cells as to result in groups of four (tetraspores), which after maturity are cast off, float away and reproduce upon germination either sexual or non-sexual new individuals.

The tetrasporangia are themselves the product of a complex division of cells arising in certain specialized branches of the mother shoot and known as stichidia. The stichidial branches may usually be recognized at an early stage of their growth from the less compact and longer celled branches which carry on the purely vegetative life of the plant. They consist at first of a row of shorter or longer segments of the cylindrical thread and end in a conical-apical cell, which persists throughout the life of the branch. With the advancing growth of this apical cell new segments are continuously being cut off from its rear end, and so the growth in length of the organ is maintained and cells destined to undergo further special changes are being constantly added, within limits.

When the stichidium has attained a certain age, the single row of cells, beginning with that one, two or three removed from the base, undergo tangential division which results in a central and from three to five radial or lateral cells. The latter remain in connection with the central cell by a thin thread of protoplasm, but are quite unconnected with one another. The next stage is the division of the radial cells by a horizontal plain at right angles to the long axis of the stichidium, into an upper and a lower cell. The upper one of these two is destined to become the tetrasporangium whilst the lower one continues its development and by further division results in a group of peripheral cells, which, by the rapid growth to large dimensions of the tetrasporangia, are much distorted and pushed into positions of least resistance. This division does not take place in all of the radial cells, generally not more than two, frequently only one tetrasporangium being formed at any one node.

During this time the central or axial cell has assumed a spindle form and from its thickest part the several protoplasmic threads extend their connections to the radial cells. From the thickest portion of these likewise, and always on the upper surface, is attached the tetrasporangium, whilst from their distal ends extend in a radiate fashion the three distorted peripheral cells. In the larger middle part of the stichidium these latter cells may undergo further division, so as nearly to enclose the tetrasporangium.

Baltimore, April 20th, 1893.

Note on the Formation of Blastostyle Buds on the Reproductive Organs of Epenthesis McCradyi. By CHARLES P. SIGERFOOS.

In 1888, Dr. W. K. Brooks, in an account of the life-history of Epenthesis McCradyi,* described a remarkable mode of reproduction in the medusæ of this species: the formation, on its reproductive organs, by budding, of true campanularian blastostyles; a mode of reproduction not before known, and remarkable because of the reversion, in the formation of blastostyles, to a more primitive stage.

The material on which Dr. Brooks based his description was collected off the coast of Nassau, in the West Indies. It was limited in amount, and as his specimens showed no very early stages in the formation of the buds there was a possibility that the blastostyles might be parasites on the reproductive organs of this Epenthesis. As it seemed desirable to study the earlier stages in detail, Dr. R. P. Bigelow collected last summer, while in Bimini, off the east coast of Florida, quite a number of blastostyle-bearing medusæ. I am indebted to him for these specimens, which were given to me for study. If the medusa described by Dr. Brooks is not identical with those collected by Dr. Bigelow, they are so nearly allied that the details in the formation of the blastostyles must be essentially the same.

The reproductive organs are almost spherical in shape, and may, it seems, develop in one of two ways. They may develop into normal reproductive organs, with either male or female cells. In this case they have essentially the structure figured by the Hertwigs (Organismus der Medusen, Table II, figs. 15 and 11). Or, they may develop into the reproductive organs bearing blastostyles. If the latter is their destination, the following changes take place. The young reproductive organ consists of a layer of small ectoderm cells covering it externally, and a layer of larger endoderm cells lining it internally. As the organ grows, the ectoderm becomes much thicker and many-layered, by the multiplication of its cells. At the same time the cells of the endoderm enlarge and become vacuolated, but still remain in a single layer. Before the organ has matured, however, the outer layer of ectoderm cells is separated off from the rest of the ectoderm, by the appearance of a supporting lamella between them. At this stage then, the organ consists of a single layer of small ectoderm cells covering it externally, and a single layer of large vacuolated endoderm cells lining it internally, and between the two, the middle mass of cells, of ectodermal origin. The structure of such a reproductive organ has been described by Dr. Brooks.

In his paper, Dr. Brooks described the endoderm of the buds as arising from endodermal tubes which lie in the middle substance of the reproductive organ. These tubes in his specimens showed no connection with the endodermal lining of the reproductive organ, and he thought them to be derived by a sort of sporogenesis from the cells of the middle mass. My sections seem to show a different origin for the tubes. When the reproductive organ is nearing maturity, evaginations of the endodermal lining push out into the middle layer as finger-shaped processes. These increase in length till they come to lie next the supporting lamella which is found between the ectodermal covering and the middle layer. But while this process is taking place, the cells of the endoderm in the finger-shaped evaginations undergo marked changes. They decrease very much in size and lose their vacuolated character, so that they acquire the structure found in the endodermal tubes described by Dr. Brooks. They soon lose their connection with the endodermal lining of the reproductive organ, and become closed cylindrical tubes of endoderm lying in the middle mass. These tubes have a distinct lumen, somewhat variable in size. After they come to lie next the ectoderm, so that they are separated from it by only the supporting lamella, important changes take place in the latter. In the interspaces between the tubes it invaginates between them, and eventually grows completely around them, and the lamella disappears between the ectoderm and the middle mass of cells.

The rudiment of the bud thus formed consists of an endodermal tube, lying in the middle mass of cells, surrounded by a supporting lamella and overlaid by ectoderm. The buds are formed as evaginations, in the usual mode of budding in Coelenterates, the ectoderm and endoderm pushing out together. *The bud is formed from both ectoderm and endoderm.* The structure of the young bud and blastostyle has been described by Dr. Brooks.

After the buds begin to form, the reproductive organ generally enlarges to several times its usual size, and may become more or less irregular in shape. The radial canals enlarge, and large quantities of food may pass into the cavity of the reproductive organ for digestion. It seems a specimen always has all of its four reproductive organs developed normally, with the usual sexual cells; or, all four may produce blastostyles. In the latter case, they are generally in different stages of development, but all may be of about the same stage. I hope to collect material in Jamaica this summer to continue this very interesting mode of reproduction.

Some Observations on Polyclonia frondosa. By R. P. BIGELOW.

The harbor at Bimini lies between the two islands and is bordered for a large part of its circumference by mangrove swamps. These swamps are penetrated everywhere by shallow channels and lagoons with soft muddy bottoms. It was in a lagoon of this sort, separated some distance from the harbor on South Bimini, that we found *Polyclonia frondosa*, Agassiz. Medusae of this species were not very abundant there, perhaps fifty individuals all told, and this was the only place in which we were able to find them. They were of various sizes from young ones half an inch in diameter to adult males and females six or eight inches across. Careful search for the attached larvae, scyphistomas, was entirely fruitless. The medusae lay upon the bottom in the position that has often been described, and when viewed from a boat were seen to vary in color and general appearance. Closer examination showed this difference to be due in part to a *sexual dimorphism.* This dimorphism is the result of an especial adaptation in the female for the protection of the eggs. In the males and immature medusae of both sexes the appendages of the oral disk have the same structure and arrangement as those of the oral arms. In the adult females on the other hand the oral funnels have disappeared from the disk while the oral vesicles have increased in number until they are closely crowded together and completely cover it. The eggs are discharged from the ovaries into the stomach, where cleavage begins. They then pass out on to the oral disk and are to be found there in great numbers cemented together in small reticulated clusters at the bases of the vesicles. They remain there until some time after they have become free ciliated planulae. I was able to collect eggs of all ages from the two-cell stage to the ciliated planulae, and I reared scyphistomas from the latter to the eight-tentacle stage. The young scyphistomas appear to be entirely similar to those of Cassiopea.

While the vesicles on the oral disk of the female serve to protect the eggs, those upon the arms have a different function, that of capturing food. If one of these vesicles be rubbed gently with a glass rod or the point of a pencil, the stimulation is followed immediately by the contraction of muscles on the side stimulated, so that the vesicle, which usually stands upright, is suddenly bent down and closes the mouth of the nearest funnel on that side like a lid. An unwary copepod striking one of these vesicles sets up the necessary stimulation to bring on this reaction. The copepod is immediately stung by the nettle cells of the vesicle, and before it can escape from them it finds itself within an oral funnel, tightly shut in by the overlying vesicle. I tried the experiment of feeding copepods to a Polyclonia, and saw them captured in this way. Remains of copepods were also to be found scattered through the great mass of mucus in the stomachs of these medusae.

The slime that surrounds the disk of the jelly fish and the cilia of the oral canals may, perhaps, serve also to entrap and convey microscopic food to the stomach. I tried to feed several specimens upon carmine suspended in the water, and was only successful with one small specimen. In this case the particles of carmine became entangled in the slime near the periphery of the umbrella, the arms were bent downward so that their branches were pressed closely to the surface of the subumbrella, and the slime containing the carmine was drawn in through the oral funnels until the stomach was full. Very soon afterwards the carmine began to stream out again. As carmine was not taken in in any but this one exceptional case, and as the remains of copepods were found normally in the stomachs of Polyclonias, it seems probable that their usual food is not microscopic material conveyed by currents of water into the oral funnels, as is often supposed, but consists of copepods captured in the way that I have described.

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* Studies from the Biol. Lab., Johns Hopkins Univ., Vol. 4, p. 147.

GENERAL SCIENTIFIC NOTES.

Note on the Protevangelium. By PAUL HAUPT.

[Abstract of a paper read before the University Philological Association, April 21, 1893.]

Gen. **3**, 15 is generally translated: *And I will put enmity between thee and the woman, and between thy seed and her seed; it shall bruise thy head, and thou shalt bruise his heel.* This is the rendering given in the A. V. It is followed by Dr. Briggs in his *Messianic Prophecy* (New York, 1891, p. 74), as well as by several of the most eminent German commentators, *e. g.*, by the late Franz Delitzsch, C. F. Keil and F. Tuch. The same translation is also found in the new German version of the O. T., edited by Prof. Kautzsch, of the University of Halle.

In the R. V. we find instead of *to bruise*, in the margin *to lie in wait for: it shall lie in wait for thy head, and thou shalt lie in wait for his heel.* This is substantially the rendering given by A. Dillmann in the various editions of his excellent commentary on Genesis. The same translation is also followed in J. D. Michaelis' translation of the O. T., part 2 (Göttingen, 1775), p. 7 (*dieser wird deinem Kopfe, und du wirst seinen Fersen nachstellen*), as well as in Peter von Bohlen's *Genesis* (Königsberg, 1835) and in K. Budde's *Bibl. Urgeschichte* (Giessen, 1883), p. 526.

The translation *to lie in wait for* is in accordance with the Septuagintal rendering of the passage: *αὐτός σου τηρήσει*[*] *κεφαλήν, καὶ σὺ τηρήσεις*[*] *αὐτοῦ πτέρναν.* Aquila, however, gives *προστρίψει* instead of *τηρήσει*, and Symmachus *θλίψει*, while the late Greek version known under the name of the *Graecus Venetus* translates: *ἐκεῖνα πλήξει σου κεφαλήν, σὺ δὲ πλήξεις αὐτοῦ πτέρναν.* In St. Jerome's *Quaestiones Hebraicae in libro Geneseos* (ed. Lagarde, Lipsiae, 1868, p. 7) we read: '*ipse servabit caput tuum, et tu servabis eius calcaneum,* melius habet in Hebraeo *ipse conteret caput tuum, et tu conteres eius calcaneum,* quia et nostri gressus propediuntur a colubro et dominus conteret satanam sub pedibus nostris velociter' (Rom. **16**, 20: *ὁ δὲ θεὸς τῆς εἰρήνης συντρίψει τὸν σατανᾶν ὑπὸ τοὺς πόδας ὑμῶν ἐν τάχει*).

So we see that the verb שוף used twice in the Hebrew text is rendered either *to bruise* and *to crush*, or *to lie in wait for.* In the Vulgate the two renderings are combined, the first שוף being translated *to crush*, and the second *to lie in wait for.* The Vulgate reads: *ipsa*[†] *conteret caput tuum, et tu insidiaberis calcaneo eius.* The verb שוף is also taken with a different meaning in each half of the sentence (*conculcabit* and *feriet*) in the Peshita (הו נרויש רישך ואנת המחיוהי בעקבָה) and in R. Saadia's Arabic version of the Pentateuch.[‡]

Most commentators admit that שוף may be rendered either *conterere* or *inhiare*, but they all seem to think that the verb cannot have a different meaning in each half of the sentence. This opinion is expressed for instance by Dillmann as well as by Delitzsch.[‖]

In my *Contributions to Assyrian Phonology* published in the Proceedings of the Royal Society of Göttingen, April 25, 1883, p. 102, I pointed out that שוף in ישופך ראש was evidently identical with the stem of the common Assyrian word for 'foot,' *šepu*,[§] adding that I failed to see why שוף could not have two different meanings in the passage; it was a case of intentional *paronomasia.* Since that time I have found a number of passages where the same word or two homonyms are used in two different meanings. A good illustration is, for instance, the beginning of the fourth chapter of Ecclesiastes, where the participle מנחם is first used in the meaning *comforter*, and then in the meaning *avenger* (= מנקם; cf. הוי אנחם מצָּרי ואנקמה מֵאויבי Is. **1**, 24 and הנה עשו אחיך מתנחם לך להרגך, Gen. **27**, 42). We must translate: *I saw (over and over) again all the oppressions that are practised under the sun; and behold the tears of the oppressed ones (were running), and there was no one to comfort them, and in the hands of their oppressors there was (brutal) force and there was no avenger* (not as the A. V. translates: *but they had no comforter*). Cf. also my translation of ψ **130**, 6 (*Hebraica* II, 101), where the second שמרים לבקר must be taken as vocative addressed to the congregation.

Biblical scholars have not paid much attention to the important question of paronomasia in the O. T. Dr. Casanowicz's thesis, which is now ready for the press, will be the first systematic treatment of the subject. Dr. Casanowicz was kind enough to send me a list of about a dozen passages in the O. T. where the same word is used in two different meanings. He also refers to the well-known passage, Math. **8**, 21: *ἄφες τοὺς νεκροὺς θάψαι τοὺς ἑαυτῶν νεκρούς, let the dead bury their dead;* i. e. let the spiritually dead bury their own relatives.

It is all the more probable that there is an intentional paronomasia in Gen. **3**, 15, as the Protevangelium belongs to JE (the Jehovistic writer). According to Dr. Casanowicz's statistics there is about one case of paronomasia to every three pages of P, the post-exilic Priestly Code (to which for instance the first chapter of Genesis belongs), while in the pre-exilic prophetical narrative JE we find a case of paronomasia on every page (see No. 98 of these *Circulars*, p. 96^b below).

The denominal verb שוף is also used in Assyrian with the meaning *to put the foot on, to tread upon, to crush.* There are two passages in the new edition of the fourth volume of Sir Henry Rawlinson's *Cuneiform Inscriptions*, which has been so admirably prepared by Mr. Theo. G. Pinches. The first is the last line of the *Additions* to col. I of pl. 15, containing an incantatory legend concerning the Seven Evil Spirits. We read there: *niše mâti ušîpû* (in the Sumerian line: *uku kurâ-kit ban-sig-eš*) 'they crushed the people of the land' (cf. עמך יהוה ישופון in the Targumic version of ψ **94**, 5 = 𝔐 עמך יהוה ידכאו).

The second passage occurs in the bilingual prayer addressed to the Goddess Istar of Erech, the reverse of which is published IV^2, 19, No. 3, while the obverse is given on pl. 4^b of the *Additions and Corrections.* We read there (the beginning is unfortunately mutilated):

OBVERSE.

* * * * * * * * * * * * * * *
* * * * * * * * * * [he destr]oyed,
* * * * * * * * * * thou hadst closed,
Sma[ll] * * * * * * * he distributed,
To E-Ulbar, the house of thy shrine, the enemy came
To thy holy mansion he went,
To thy holy place did he direct his steps.
Thy noble dwelling * * * * * * they destroy.
* *

REVERSE.

How long, my lady, hath the powerful enemy spoiled thy shrine?[*]
A drought hath come over thy chief city, even Erech,
But in E-Ulbar, the temple of thine oracle, blood is poured out like water.
All thy countries hath he set on fire, he hath made them go up in smoke.
O! my lady, I am yoked fast to misfortune.
Thou hast compassed me about, hast made me wretched,
So that the strong enemy could crush me like a single reed.
I cannot form a resolution, I cannot think.
I lament like a canebrake night and day,
I, thy servant, pray unto thee,
Let thy heart be quieted, let thy mind be appeased.
* * * * * lamentation, (let) thy heart (be quieted),
* * * * * * * * *, (let) thy heart (be quieted)
[To thy servant, my lady, turn] to him [thy face]!
* * * * * * * * * * * * * * * * * * *

Dr. Zimmern in his excellent work on the Babylonian Penitential Psalms (p. 57, l. 55) translates correctly *he has trodden me down*, but he adopts Professor Delitzsch's conjecture, reading *udîšannî*, from דוש *to tread down*, the same verb with which the Peshita translates ישופך in the Protevangelium.

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[*] Var. *τειρήσει, τηρήση* and *τειρήσεις, τηρήσης.* Cf. Lagarde's *Genesis Graece* (Lipsiae, 1868), p. 10, and his *Ankündigung einer neuen ausgabe der griech. übersetzung des A. T.* (Göttingen, 1882), p. 36.

[†] *Ipsa*, referring to the Virgin Mary, is a dogmatic correction instead of *ipse.* According to the Hebrew original the masculine *ipse*, referring to the seed, is the only correct rendering. The masculine suffix in תשופנו proves that beyond all doubt.

[‡] See also Lagarde's *Materialen sur Kritik und Geschichte des Pentateuchs*, part I (Leipzig, 1867), p. 4, l. 33 (cf., on the other hand, part II, p. 41, l. 33).

[‖] Cf., on the other hand, Wellhausen, *Prolegomena*, 3d ed. (Berlin, 1886), p. 313: *die Schlange soll im ungleichen Kampfe mit dem Menschen zu Grunde gehen.*

[§] *Šepu* (plene *še-e-pu* IV^2 27, 32b) is a formation like *kenu* 'righteous' (Syriac *kênâ*, Nöld. *Syr. Gram.*, §§ 46, 98 C) from כון. Franz Delitzsch, *Gen.*^{5}, 106, n. 1. (Engl. ed., p. 162) seems to derive *šepu* from a stem שפף, which is impossible. Nor does *šepu* mean *terens, conterens, calcans*, as Delitzsch would have it, but שוף *conterere, conculcare*, is a denominal verb derived from *šepu.*

[*] Assyr. *maštak-ki imšu'* from א$_4$ש$_2$מ, *mašâ'u* II, 48, 60c; cf. IV^2 15, 57a (see *Additions and Corrections*, pl. 3a, l. 16).

The reading *ušîpannî*,* however, as given in Pinches' new edition of the text (cf. the plate in Vol. I, No. 2, of BOR, Dec., 1886) is unquestionably correct.

Nor do I think there can be any doubt that ישופך in the Protevangelium has the same meaning as *ušîp* in the two cuneiform passages quoted. תשופנו in the second hemistich, on the other hand, must be taken in the sense of the stem שאף *inhiare, to snap at.*†

I would, therefore, translate Gen. **3**, 15: *I will put enmity between thee and the woman, and between thy seed and her seed. It will put its foot upon thy head while thou wilt snap at its heel.*

Note on K. 84. By Christopher Johnston.

In a paper on "Two Assyrian Letters" published in the Journal of the American Oriental Society, Vol. XV, pp. 311–316, I stated that these letters had not hitherto been translated. While this statement is correct as regards the first letter (K. 828), it should be modified with regard to the second (K. 84) inasmuch as a translation of this text, accompanied by a transliteration, was published by Mr. Theo. G. Pinches in the new series of Records of the Past, Vol. II (1889), pp. 185 ff. I am indebted to the Rev. Dr. W. Muss-Arnolt, of the University of Michigan, for calling my attention to this fact. At the time my paper was written, I did not have access to Mr. Pinches' translation. After a careful perusal of Mr. Pinches' translation I see no reason to modify the rendering proposed by me. In fact Mr. Pinches' rendering is hardly such as we should expect from a scholar of so high a standing in the domain of Assyriology. Translations like "The words which the wind now for the third time has spoken to you" (ll. 3–4) instead of *the lying words which this unnatural brother has spoken to you;* "Ye cannot govern the wind" (1, 6) for *It is falsehood, trust him not:* and "the equivalence of the word, which ye are treasuring up in your hearts I know" (ll. 25–26) for *I know that thing which ye think in your hearts,* will hardly commend themselves even to a non-Assyriologist. The writer of the letter could hardly have meant to tell the Babylonians that their very name was so odious to him that he could not bear to hear it (ll. 12–14) and then immediately assure them (l. 18) that they were "near to his heart." The reading *šalašiš agâ* in line 4 which Mr. Pinches renders "for the third time now" is quite impossible. The ordinal adverb "third" is *šalsiš* not *šalašiš; agâ* means not "now," but "this;" and the correct reading *ša la axu agâ* "which this unnatural brother (has spoken)" is to be found in Delitzsch's Assyrian Dictionary, p. 76, which was published in 1887, two years before Mr. Pinches' translation of the text appeared. In line 22 by reading *banû* "make" instead of its homonym *banû* "bright, spotless" (cf. Zimmern: Babylonische Busspsalmen p. 37, n. 2), Mr. Pinches has missed the whole force of the passage, in which the Babylonians are urged not to sully their hitherto spotless reputation by involving themselves in treasonable plots. Lines 27–29 are translated "we will ignore the tax, it is turned into our tribute" which will hardly convey any very distinct idea to the minds of most readers. The passage should be rendered *(ye say) Lo! because we are obnoxious to him he adds to our taxes.* The succeeding lines (25–35) are thus translated: "That is no tribute; it is not that ye have equalised to my slanderer the matter of 'Corban and tax,' it is that the payment of tribute lies with yourselves, and failure concerning the agreement is before God." What this means it is difficult to say. The meaning of the text, however, is quite clear. *'Tis no tax* (says the writer). *The qurbânû is nothing but a name, and because ye have taken sides with my adversary ye choose to consider this as imposition of taxes and sinning against the oaths sworn before God.* The point, which Mr. Pinches has failed to see, is that certain imposts complained of by the Babylonians as levied in direct violation of some special sworn agreement, are in reality not a *biltu* or state tax, but a *qurbânû* or religious tax, doubtless for the support of their own temples.

While I must differ with Mr. Pinches in his translation of this text, it is with regret that I cannot be in accordance with a scholar who has rendered so many distinguished services to the cause of science, and has made all students of Assyriology his debtors by his most excellent work in the preparation and revision of the second edition of the Cuneiform Inscriptions of Western Asia.

Messianic Psalms. By Daniel G. Stevens, Jr.

[Abstract of a paper read before the University Philological Association, April 21, 1893.]

Prominent among the thoughts characteristic of Old Testament teachings is the anticipation of a time to come when salvation and dominion would be procured for God's people through a King, divinely anointed and receiving divine support. This Messianic hope forms an especial feature in the predictions of the Prophets; and in the Psalter its presence is likewise to be observed. Here occur several Songs which, on account of the expressions and allusions they contain, have been classified as being in particular Messianic Psalms. They are Pss. 110. 2. 45. 72. 22. 40. 16. 8. 69. In the New Testament many passages from these Psalms are referred, directly or implicitly, to Christ; and most modern exegetes explain them as prophecy of the Messiah, or at least as containing language in some way applicable to Him. But the question for the interpreter to decide does not concern the possible application, but rather the idea which existed in the mind of the original author. To discern this, recourse must be had to the Psalms themselves. For, obviously, the words of the original, fairly explained, are the only standard by which the question of import is to be tried.

While in the case of certain expressions the Messianic interpretation is not inapt, at the same time a strict examination of the Psalms reveals that the more immediate significance of the words is lost sight of, or, in order to contain a Messianic allusion, requires a spiritual metamorphosis not suggested in the Songs themselves. It appears that the Messianic interpretation fails to account satisfactorily for the Songs in their entirety, and even the very phrases and terms that seem to justify reference to the Messiah, easily obtain, in the light of Old Testament usage, an exposition of their meaning more in accord with the context. In short, the explanation of these Psalms as prophecy of the Messiah seems less natural and rather forced, while, on the other hand, the connection between the parts of the individual Songs, is clearly brought out, by explaining them, on the basis of the descriptions they contain, as referring to actual historical occurrences and personages.

Illustration was at this point introduced in support of the preceding statements by an examination of several Psalms; the paper then concluded as follows:

It is not surprising that, in the use of the Psalter as the hymn-book of the second Temple, these Songs should have received the interpretation that has been handed down, since to the Church the Messiah was the ideal King, clothed with unlimited power and authority, the husband of the Israel of God, in whom would be fulfilled the hyperbolical prophecies which could never receive literal accomplishment in an ordinary monarch. Any reference to the Messianic time became to the congregation the predominant feature of the whole piece, to the consequent obscuration of the original meaning. But the contents of the Psalms still seem to bear witness to what the authors had in mind, and reveal the varying nature of the themes, in some cases purely secular, in others, matters concerning the fortunes of Israel, the congregation of God.

A New Theory of Light Sensation. By Christine Ladd Franklin.

[Abstract reprinted from the Proceedings of the International Congress of Experimental Psychology, London, 1892.]

The reasons which make it impossible for most people to accept either the Hering or the Young-Helmholtz theories of light sensation are familiar to every one. The following are the most important of them:—

The Young-Helmholtz theory requires us to believe: (*a*) something which is strongly contradicted by consciousness,—viz., that the *sensation* white is nothing but an even mixture of red-green-blue *sensations;* (*b*) something which has a strong antecedent improbability against it,—viz., that under certain definite circumstances (*e. g.,* for very ex-centric parts of the retina and for the totally color-blind) all three color-sensations are produced in exactly their original integrity, but yet that they are never produced in any other than that *even* mixture which gives us the sensation of white; (*c*) something which is quantitatively quite impossible,—*viz.,* that after-images, which are frequently very brilliant, are due to nothing but what is left over in the self-light of the retina after part of it has been exhausted by fatigue, although we have otherwise every reason to think that the *whole* of the self-light is excessively faint.

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* Pinches (BOR I 22, l. 14) translates *has smitten* (?) *me down*; Delitzsch (AW, 1): *hat mich zerbrochen.*

† Cf. האר and הור &c. The new Hebrew Lexicon by Siegfried & Stade rightly says *s. v.* שאף: *In der Überlieferung wahrscheinlich von* שוף *nicht correct geschieden*, cf. Lag. *Proph. chald.* XLVIII (ψψ 56, 2, 3; 57, 4 *non* שָׁאַף *sed* שׁוּף *poeta voluerat*); Bleek, *Einl.*^{5} 589; Wellhausen, *Skizzen und Vorarbeiten*, part V (Berlin, 1892), p. 72. It is undoubtedly true that several forms which are generally referred to שאף must be derived from שוף.

The theory of Hering avoids all of these difficulties of the Young-Helmholtz theory, but at the cost of introducing others which are equally disagreeable: it sins against the first principles of the physiologist by requiring us to think that the process of building up highly organized animal tissue is useful in giving us knowledge of the external world instead of supposing that it takes place (as in every other instance known to us) simply for the sake of its future useful tearing down; it necessarily brings with it a quite hopeless confusion between our ideas of the *brightness* and the *relative whiteness* of a given sensation (as is proved by the fact that it enables Hering to re-discover, under the name of the specific brightness of the different colors, a phenomenon which has long been perfectly well known as the Purkinje phenomenon); the theory is contradicted (at least the present conception of it) by the following fact,—the white made out of red and green is *not the same thing* as the white made out of blue and yellow; for if (being mixed on the color-wheel) these two whites are made equally bright at an ordinary intensity, they will be found to be of very different brightness when the illumination is made very faint.

Nevertheless, the theory of Hering would have to be accepted, if it were the only possible way of escape from the difficulties of the Young-Helmholtz theory. But these difficulties may be met by a theory which has the following for its principal assumptions.

In its earliest stage of development, vision consisted of nothing but a sensation of grey (if we use the word grey to cover the whole series black-grey-white). This sensation of grey was brought about by the action upon the nerve-ends of a certain chemical substance, set free in the retina under the influence of light. In the course of development of the visual sense, the molecule to be chemically decomposed became so differentiated as to be capable of losing only a part of its exciting substance at once; three chemical constituents of the exciter of the grey-sensation can therefore now be present separately (under the influence of three different parts of the spectrum respectively), and they severally cause the sensations of red, green and blue. But when all three of these substances are present at once, they recombine to produce the exciter of the grey sensation, and thus it happens that the objective mixing of three colors, in proper proportions, gives a sensation of no *color* at all, but only grey.

This theory is found, upon working it out in detail, to avoid the difficulties of the theories of Helmholtz and of Hering.

Its assumption of a separate chemical process for the production of the sensation of grey gives it the same great advantage over the Young-Helmholtz theory that is possessed by the theory of Hering; it enables it, namely, to account for the remarkable fact that the sensation of grey exists unaccompanied by any sensation whatever of color under the five following sets of circumstances—when the portion of the retina affected is very small, when it is very far from the fovea, when the illumination is very faint, when it is very intense, and when the retina is that of a person who is totally color-blind. This advantage my theory attains by the perfectly natural and simple assumption of a *partial* decomposition of chemical molecules; that of Hering requires us to suppose that sensations so closely related as red and green are the accompaniments of chemical processes so dissimilar as the building up and the tearing down of photo-chemical substances, and farther that two complementary colors call forth photo-chemical processes which destroy each other, instead of combining to produce the process which underlies the sensation of grey.

Of the first four of the above enumerated cases, the explanation will readily suggest itself; in the case of the totally color-blind it is simply that that differentiation of the primitive molecules by which they have become capable of losing only a part of their exciting substance at one time has not taken place; the condition, in other words, is a condition of atavism. In partial color-blindness, and in the intermediate zones of the retina in normal vision, the only colors perceived are yellow and blue. This would indicate that the substance which in its primitive condition excites the sensation of grey becomes in the first place differentiated into two substances, the exciters of yellow and blue respectively, and that at a later stage of development the exciter of the sensation of yellow becomes again separated into two substances which produce respectively the sensations of red and of green. In this way the unitary (non-mixed) character of the sensation yellow is accounted for by a three-color theory as completely as by a four-color theory. A three-color theory is rendered a necessity by the fact that it alone is reconcilable with the results of König's experiments for the determination of the color-equations of color-blind and of normal eyes,[*] experiments which far exceed in accuracy any which have yet been made in color-vision, but which owing to the intricate character of the theoretical deductions made from them, have not hitherto been allowed their due weight in the estimation of color theories.

The explanation which the theory of Hering gives of after-images and of simultaneous contrast are not explanations at all, but merely translations of the facts into the language of his theory. My theory is able to deal with them more satisfactorily; when red light, say, has been acting upon the retina for some time, many of the photo-chemical molecules have lost that one of their constituents which is the exciter of the red sensation; but in this mutilated condition they are exceedingly unstable, and their other two constituents (the exciters of the sensations of blue and of green) are gradually set free; the effect of this is that, while the eyes are still open a blue-green sensation is added to the red sensation with the result of making it gradually fade out into white, and, if the eyes are closed, the cause of the blue-green sensation persists until all the molecules affected are totally decomposed. Thus the actual course of the sensation produced by looking at a red object,—its gradual fading out, in case of careful fixation, and the appearance of the complementary color if the illumination is diminished or if the eyes are closed,—is exactly what the original assumption of a partial decomposition of molecules would require us to predict. The well-known extreme rapidity of the circulation in the retina would make it impossible that the partly decomposed molecules just referred to should remain within the boundaries of the portion of the retina in which they are first produced; and their completed decomposition after they have passed beyond these boundaries is the cause of the complementary color-sensation which we call simultaneous contrast. The spreading of the actual color which succeeds it would then be accounted for, as Helmholtz suggests, by a diffusion of the colored light in the various media of the eye.

No effort has hitherto been made to explain a very remarkable feature in the structure of the retina,—the fact that the retinal elements are of two different kinds, which we distinguish as rods and cones. But this structure becomes quite what one might expect, if we suppose that the rods contain the undeveloped molecules which give us the sensation of grey only, while the cones contain the color molecules, which cause sensations of grey and of color both. The distribution of the rods and cones corresponds exactly with the distribution of sensitiveness to just perceptible light and color excitations as determined by the very careful experiments of Eugen Fick.[†]

Two other theories of light sensation have been proposed besides the one which I have here outlined, either one of which meets the requirements of a possible theory far better than that of Hering or of Helmholtz; they are those of Göller [‡] and Donders. [‖] The former is a physical theory. That of Donders is a chemical theory, and very similar to the one which I here propose. Every chemical theory supposes a tearing down of highly complex molecules; Donders' theory supposes in addition that the tearing down in question can take place in two successive stages. But Donders' theory is necessarily a four-color theory; and Donders himself, although the experiments of König above referred to had not at that time been made, was so strongly convinced of the necessity of a three-color theory for the explanation of some of the facts of color-vision that he supplemented his four-process theory in the retina with a three-process theory in the higher centres. The desirableness, therefore, of devising a partial decomposition of molecules *of such a nature* that the fundamental color-processes assumed can be three in number instead of four is apparent.

But the theory of Donders is open to a still graver objection. The molecules assumed by him must, in order to be capable of four different semi-dissociations, consist of at least eight different atoms or groups of atoms. The red-green dissociations and the yellow-blue dissociations we may then represent symbolically by these two diagrams respectively:

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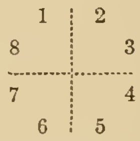
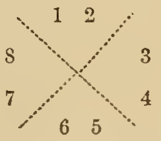
[*] A. König und C. Dieterici, *Sitzungberichte der Berl. Akad.* vom 29. Juli, 1886.

[†] Studien über Licht und Farbenempfindung. *Pflüger's Archiv*, Bd. XLIV, s. 441, 1888.

[‡] Die Analyse der Lichtwellen durch das Auge. *Du Bois-Reymond's Archiv*, 1889.

[‖] Noch einmal die Farben-systeme. *Gräfe's Archiv für Ophthalmologie*, Bd. 30 (1), 1884.





But it will be observed that the two completed dissociations end by having set free *different* combinations; in the one case 1 is combined with 2 and in the other case 1 is combined with 8, etc. If, now, the partial dissociations are so unlike as to cause sensations of yellow and blue (or of red and green) it is not probable that completed dissociations which end in setting free *different* chemical combinations should produce the *same* sensation, grey. The difficulty introduced by Donders' theory is therefore (as in the case of Hering's theory) as great as the difficulty sought to be removed. It is the desire to secure the advantages of a partial dissociation theory, without the disadvantages of the theory of Donders that has led me to devise a partial dissociation of molecules of a different kind. The theory will be found more explicitly set forth in the next number of the *Zeitschrift für Psychologie.*

In Professor SCHROEDER'S recent work on the Algebra of Logic (*Vorlesungen über die Algebra der Logik*, E. Schroeder, Leipzig, 1891—[the second volume is not wholly out yet]) § 43 is on *Miss Ladd's rechnerische Behandlung der 15 gültigen Modi.* In this section he says (p. 228): "Es ist das Verdienst [of Miss Ladd] die gültigen Syllogismen auf einen gemeinsamen Ausdruck gebracht zu haben, dieselben auf eine Weise die wir jetzt darlegen wollen, mit einer einzigen Formel zu begründen. . . . . In der Art wie diese Zurückführung nun ausgeführt wird (an der noch die Boole'sche Disziplin scheiterte) wird man nicht umhin können einen ganz erheblichen Fortschritt zu erblicken. . . . . p. 234. Ich hege die Ueberzeugung dass es nicht möglich sein wird, die Syllogistik jemals in einer *schöneren* Weise zu erledigen, als es durch Miss Ladd begründet ist, wie wir vorstehend darzustellen versucht haben: in weniger als *eine* Formel lassen die Syllogismen sich zuverlässig nicht komprimiren, und dabei an Durchsichtigkeit und Einfachheit die Formel A noch zu übertreffen erscheint undenkbar."

A New Table of Standard Wave-Lengths. By HENRY A. ROWLAND.

[The April, 1893, number of "Astronomy and Astro-Physics" contains "A New Table of Standard Wave Lengths" by Professor Henry A. Rowland.

Those who have the Photographic Map of the Solar Spectrum by Professor Rowland are advised to secure this table which may be had from the publishers of "Astronomy and Astro-Physics," Northfield, Minn.

Professor Rowland's prefatory note is herewith reprinted.]

During the last ten years I have made many observations of wave-lengths, and have published a preliminary and a final table of the wave-lengths of several hundred lines in the solar spectrum.

For the purpose of a new table I have worked over all my old observations, besides many thousand new ones, principally made on photographs, and have added measurements of metallic lines so as to make the number of standards nearly one thousand.

Nearly all the new measurements have been made on a new measuring machine whose screw was specially made by my process* to correspond with the plates and to measure wave-lengths direct with only a small correction.

The new measures were made by Mr. L. E. Jewell, who has now become so expert as to have the probable error of one setting about $\frac{1}{1000}$ division of Angström, or 1 part in 5000000 of the wave-length. Many of these observations, however, being made with different measuring instruments, and before such experience had been obtained, have a greater probable error. This is especially true of those measurements made with eye observations on the spectrum direct. The reductions of the reading were made by myself.

Many gratings of 6 in. diameter and 21½ ft. radius were used; and the observations were extended over about ten years.

The *standard* wave-length was obtained as follows: Dr. Bell's value of D_1 was first slightly corrected and became 5896.20. C. S. Peirce's value of the same line was corrected as the result of some measurements made on his grating and became 5896.20. The values of the wave-length then become

Weight.	*Observer.*	*D.*
1	Angström, corrected by Thalen	5895.81
2	Müller & Kempf	5896 25
2	Kurlbaum	5895.90
5	Peirce	5896.20
10	Bell	5896.20
	Mean	5896.156

As the relative values are more important for spectroscopic work than the absolute, I take this value without further remark. It was utilized as follows:

1st. By the method of coincidences with the concave grating, the wave-lengths of 14 more lines throughout the visible spectrum were determined from this with great accuracy for primary standards.

2d. The solar standards were measured from one end of the spectrum to the other many times; and a curve of error drawn to correct to these primary standards.

3d. Flat gratings were also used.

4th. Measurements of photographic plates from 10 to 19 inches long were made. These plates had upon them two portions of the solar spectrum of different orders. Thus the blue, violet and ultra-violet spectra were compared with the visible spectrum, giving many checks on the first series of standards.

5th. Measurements were made of photographic plates having the solar spectrum in coincidence with metallic spectra, often of three orders, thus giving the relative wave-lengths of three points in the spectrum.

Often the same line in the ultra-violet had its wave-length determined by two different routes back to two different lines of the visible spectrum. The agreement of these to $\frac{1}{100}$ division of Angström in nearly every case showed the accuracy of the work.

6th. Finally, the important lines had from 10 to 20 measurements on them, connecting them with their neighbors and many points in the spectrum, both visible and invisible; and the mean values bound the whole system together so intimately that no changes could be made in any part without changing the whole.

This unique way of working has resulted in a table of wave-lengths from 2100. to 7700 whose accuracy might be estimated as follows:

Distribute less than $\frac{1}{100}$ division of Angström properly throughout the table as a correction, and it will become perfect within the limits 2400 and 7000.

The above is only a sketch of the methods used. The complete details of the work are ready for publication but I have not yet found any journal or society willing to undertake it.

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* See *Encyc. Brit.*, Art. *Screw.*

UNIVERSITY CALENDAR.

The final Examinations of Candidates for the degree of Doctor of Philosophy before the Board of University Studies were held May 26–31.

The University Examinations of Undergraduate Students began Wednesday, May 24, and will continue until Tuesday, June 6.

The Matriculation Examinations will be held on Wednesday, Thursday, and Friday, June 7, 8, 9, and on Monday, Tuesday, and Wednesday, October 2, 3, and 4.

Degrees will be conferred, on the graduates of the year, on Tuesday, June 13, at 5 p. m.

The eighteenth academic year begins on Monday, October 2, 1893.

The Annual Register of the University, and the University Circular, No. 107, containing announcements of the courses offered for the next academic year, may be had on application.

THE JOHNS HOPKINS PRESS.

A MEMOIR ON THE GENUS SALPA.

By W. K. Brooks, Ph. D.
Professor of Zoölogy in the Johns Hopkins University.

The Johns Hopkins Press announces for early publication a Memoir on the Genus Salpa by Professor W. K. Brooks. It will contain about three hundred and fifty pages quarto, with sixty colored plates. The memoir is based for the most part upon material collected by the United States Fish Commission.

TABLE OF CONTENTS.

Part I.—A General Account of the Life History of Salpa.—Chapter I. Introductory. Chapter II. The Development of the Solitary Salpa from the Egg. Chapter III. The Morphological Significance of the Salpa Embryo. Chapter IV. The Origin of the Proliferous Stolen. Chapter V. The Transformation of the Stolon into the Series Aggregated of Salpæ.

Part II.—The Systematic Affinity of Salpa in its relation to the Conditions of Primitive Pelagic Life; The Phylogeny of the Tunicata; and the Ancestry of the Chordata.—Chapter VI. The Systematic Position of Salpa. Chapter VII. Salpa in its Relation to the Evolution of Life. Chapter VIII. The Origin of the Chordata, considered in its Relation to Pelagic Influences.

Part III.—A Descriptive and Critical Discussion of the Asexual and Sexual Development of Salpa.—Chapter IX. The Origin and Maturation of the Egg of Salpa. Chapter X. Sex in Salpa. Chapter XI. Fertilization and Segmentation. Chapter XII. The Foetal Membranes. Chapter XIII. The Follicle. Chapter XIV. The Ontogeny of the Organs of Salpa.

Part IV.—By M. M. Metcalf. The Eye and Sub-neural Gland of Salpa.

Advance Orders will now be received. The edition will be limited. The price is fixed at $7.50 net.

PROCEEDINGS OF SOCIETIES.

Philological Association.

May 19.—One hundred and twenty-seventh regular meeting. Professor Gildersleeve in the chair. Thirty-three members present.

Papers read:

On the so-called Root-determinatives in the Indo-European Languages, by M. Bloomfield.

The Source of Bojardo's Orlando Innamorato, book ii, cantos vii–ix, and on the Italian and English idioms meaning "to take time by the forelock," by J. E. Matzke.

Historical and Political Science Association.

Meetings April 28 *and May* 19.

The Separation of West Virginia, by J. R. Brackett.
The Struggle for Toleration in Virginia, by H. R. McIlwaine.
Contemporary American Opinion of the French Revolution, by C. D. Hazen.

Baltimore Naturalists' Field Club.

May 9.

Malformation of leaves of Hepatica by B. W. Barton.
Abnormalities of Viola, by C. E. Waters.
Notes on Marsillia Pond, by E. A. Andrews.

Physical Seminary.

Measurements of High and Low Temperatures, by A. P. Porter.
Atmospheric Electricity, by W. C. Day.
Metallic Reflection, by W. J. Raymond.

Young Men's Christian Association.

April 24.—Members' Reception.
May 23.—Final Meeting of the Year.
May 26.—Last observance of Morning Prayer for the Academic Year.

A friend of the Association has recently given to its library 60 volumes, including the Cambridge Bible, the Expositor's Bible, Julian's Dictionary of Hymnology, Stanley's History of the Jewish Church and other volumes of interest and importance to biblical students. Gifts have also been received from Mrs. Margaret Woods Lawrence of Baltimore, and Mr. W. J. Rivers, formerly of South Carolina.

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THE JOHNS HOPKINS PRESS.

THE SACRED BOOKS OF THE OLD TESTAMENT IN HEBREW.

A New Critical Edition prepared by Eminent Scholars of Europe and America under the Editorial Direction of Professor **PAUL HAUPT, Ph. D.**

The first part of this new critical edition, containing the Book of Job, with Notes by Professor C. Siegfried, of the University of Jena, is now ready. There is an English translation of the Notes by Professor R. E. Brünnow, of Heidelberg. This part will be sent, postage paid, for one dollar.

The part consists of fifty-two pages—twenty-seven of these being the Hebrew text printed in three colors—red, green and blue, illustrating the composite structure of the book, as stated below. Twenty-one pages contain critical notes giving the reasons for the emendations introduced into the text. There is also a concordance showing the correspondence between the traditional order and the new arrangement adopted. The poetic portions of the Hebrew text are arranged in lines in double columns. The text has been left unpointed except in ambiguous cases.

The printing in colors is done according to a new process invented by Professor Haupt. The passages printed in different colors are not printed with different inks, but are placed in blocks of different colors so that the clear black type appears on a colored back-ground. In this way it is possible to use light transparent colors which can be easily distinguished even by artificial light, without impairing the neatness and legibility of the printed text.

The edition will be printed by the firm of J. C. Hinrichs of Leipsic, in the best style of typography, and each of the parts will be well bound.

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